ASSOCIATION BETWEEN HEIGHT AT AGE 2 YEARS AND ADOLESCENCE SHOOL PERFOMANCE: EVIDENCE FROM BIRTH TO TWENTY BIRTH COHORT STUDY

Palesa Manthabiseng Nkomo

Supervisors: Shane A. Norris, PhD; Carren Ginsburg, MSc.

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of

Master of Science in Medicine in the field of Epidemiology and Biostatistics

October, 2010

DECLARATION

I, Palesa Manthabiseng Nkomo declare that this research report is my own work. It is been submitted for the degree of Master of Science in Medicine in the field of Epidemiology and Biostatistics in the University of Witwatersrand, Johannesburg, South Africa. This research report has not been submitted before for any degree or examination at this or any other university.

Signature: PMNkomo

02 day of November 2010

DEDICATION

This research report is dedicated to my late grandmothers Mrs Isabella Stofile and Mrs Cikizwa Virginia Nkomo who believed in me even as a child and who were a great source of stability in my early years.

I also wish to dedicate this research report to my family and friends for their support and encouragement during the entire duration of my study.

Most of all, I wish to thank God for His love, guidance, blessings and protection.

ABSTRACT

Background

The first two years of a child's life are crucial for cognitive development. In societies where there are high rates of poverty, children are at risk of under-nutrition and subsequently stunting. Insufficient nutrition in early childhood results in growth retardation in young infants and subsequently weak school performance later in life due to poorer cognitive development**.** As far as we know no study has been conducted in South Africa to examine the association between height at age 2 years and school performance at the end of primary school.

Purpose

The primary objective of this study was to investigate the association between growth at age 2 years and education performance (school performance in Mathematics and English or first language) of adolescents at the end of primary school (grade 7). In addition, other growth variables such as weight-for-age, BMI-for-age and weight-for-height were tested for the association as a secondary objective. Prevalence of stunting, underweight, wasting and obesity at age two years was also investigated.

Methods

This study is a primary analysis of historical data collected from Birth to Twenty (BT20) cohort in Johannesburg, South Africa. A cohort study conceptualised to investigate the effects of the urbanization and societal transition on health and development A longitudinal study design within the BT20 cohort was employed. A total of 252 study participants were included in the study.

An ordinal logistic model was used to test for association between growth at age two years and school performance. Potential confounders such as maternal education, birth weight and socio-economic status as defined by household assets were adjusted for in the model.

Results

At age two years, about 29% of the study participants were stunted as defined by height-for-age, based on the WHO 2006 growth standards. The proportion of girls defined as stunted was equal to that of boys. Levels of underweight, wasting and obesity were 9%, 6% and 2% respectively.

The risk of low versus combined high and average performance in Mathematics at grade 7 was about three times more likely in study participants whose height-for-age was below -3SD and seven times more likely for those below -4SD. Participants whose weight-for-age as defined by the WHO reference was below -2SD were more than three times more likely to achieve a low score versus a combined high and average score in English or first language. There was no evidence of correlation between low birth weight, wasting and obesity and poor education performance for both Mathematics and English results

Conclusion: We conclude that there is an association between height at age 2 years and school performance at the end of primary school.

ACKNOWLEDGEMENTS

I wish to extend my heartfelt gratitude to my supervisors Professor Shane A. Norris and Ms Carren Ginsburg for their kind guidance, prompt and valuable comments throughout the process of this research report.

I would also like to thank Professor Kathy Kahn for her input at the beginning of the project, Mr. Edmore Marinda for all his assistance, and the entire staff of Birth to Twenty (with special thanks to Ms Zandile Lephoto and Mr Matthew Mainwaring for their assistance in data selection) for allowing me to use their data for this research report.

My heartfelt gratitude is also extended to the entire staff of School of Public Health, Faculty of Health Sciences and the fellow students for their assistance in the planning and implementation stages of this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table **Page**

ABBREVIATIONS

AIDS = Acquired immune deficiency syndrome

BMI = Body mass index

BT10 = Birth-to-10

BT20 = Birth-to-20

CI = Confidence interval

KZN = Kwa-Zulu Natal

IQ = Intelligence Quotient

IUGR = Intrauterine growth restriction BMI = Body Mass Index

LMICs = Low- Middle Income Countries

MDG = Millennium Development Goals

NBW = Normal Birth Weight

OR = Odds ratio

PFBG = Preliminary Food-Based Dietary Guidelines

SAVACG = South African Vitamin A Consultative Group

SD = Standard deviation

SIDS = Sudden Infant Death Syndrome

VLBW = Very Low Birth Weight

WHO = World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

A longitudinal study from the Philippines where anthropometric and dietary data were collected twice a month on more than 2000 children during the first years of their lives and followed up when the children were 8 and 11 years old showed that children who are stunted between birth and 2 years of age scored lower in tests of cognitive ability compared to children who are not stunted[1].

Grantham-McGregor and colleagues (2007) estimate that globally more than 200 million children under the age of five years are affected by poverty, poor health and nutrition, and deficient care, and as such are not able to reach their cognitive developmental potential[2]. There is significant data showing an association between stunting, cognitive development and education performance. However, there is still paucity of data in low-and middle-income countries (LMICs) investigating the association between stunting at two years old and its effect on education performance in later years.[3]

Under-nutrition is defined as poor dietary intake and deficiency in nutrients, and it is particularly prevalent in LMICs[4]. Under-nutrition is of great concern because lack of appropriate nutrition in the first two years of a child's life can lead to permanent physical and cognitive damage[3]. During pregnancy, under-nutrition includes various effects including intrauterine growth restriction (IUGR) which results in low birth weight. If these are not addressed, they can have serious ramifications for the developing infant. For example, they can results in underweight - characterised by low weight-for-age; stunting - defined as “chronic restriction of growth in height indicated by a low height-for-age”; wasting - indicated by weight loss shown by a low weight-for-height and other micronutrient deficiencies.[5] Indicators for poor development are stunting (“early childhood growth retardation”), defined as height-for-age less than 2 standard deviations (SD) according to the World Health Organization growth standards[6].

The purpose of this report is to conduct a primary analysis of historical data collected on the largest and longest running longitudinal birth cohort in Africa, Birth-to-Twenty (BT20), so as to investigate the association between stunting at age 2 years and education performance in early adolescence as the primary objective and association between other growth variables such as weight-for-age; BMI-for-age and weight-for-height and school performance as a secondary objective.

Depicted in the theoretical framework below (Figure 1.1) is the impact of under-nutrition on child development with poverty as the fundamental factor. Poverty influences the socio-economic status and the level of education acquired by the pregnant mother. This in turn determines her access to information and good nutrition necessary during pregnancy, which has both long- and- short term consequences for the unborn child.[1,2-7,12,16,24,53] However, for the purpose of this research report we will explore the interrelationship between growth (as a proxy of nutrition) and cognitive development.

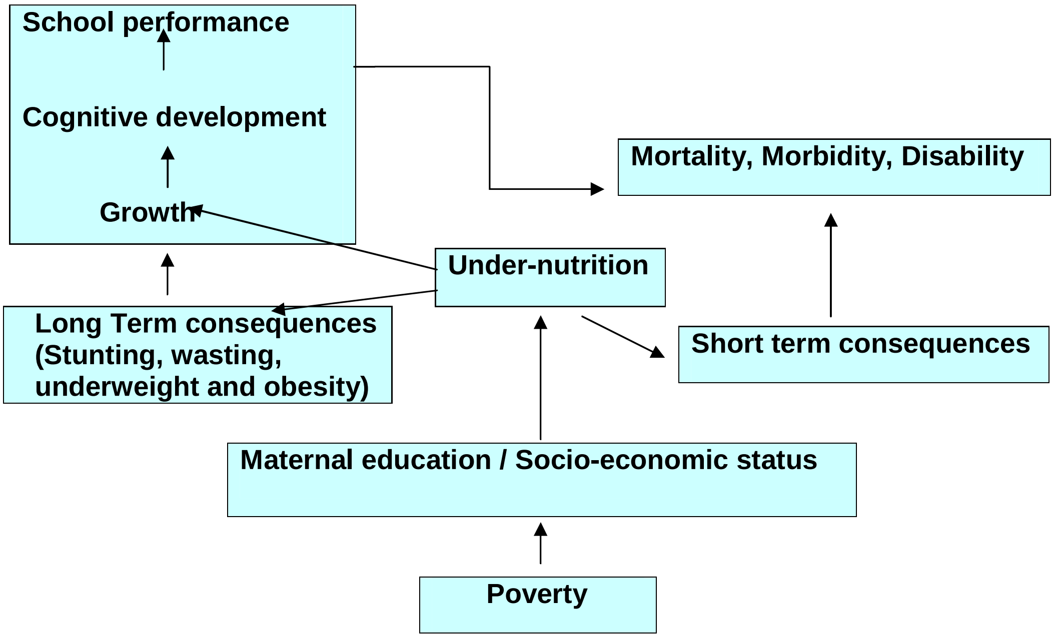

Figure 1.1 Theoretical Conceptual framework of association between growth and school performance

1.2 Statement of the problem

It is estimated that 178 million children worldwide under the age of five years are stunted. A great majority of them are from south-central Asia and sub-Saharan Africa. The prevalence of stunting is estimated at over 50% in least developed nations.[7]

Stunting is a possible problem for post-apartheid South Africa and its prevalence shows that all the social and economic changes that have taken place have not quite translated into child growth, and even though it was expected that child growth may take some time – it has proven to take even longer time than it was anticipated.[8] This is of great importance as “human growth is recognised as a sensitive barometer of change” [8].

Dr. Horton (2008) says that, four-fifths of undernourished children live in just 20 countries and of those, the countries in most need of an intervention are Burma, Uganda, India, and South Africa[9].

Consistent with Dr Horton’s assertion, in 1995 a study was conducted by the South African Vitamin A Consultative Group (SAVACG) to measure prevalence of stunting in urban areas compared to rural areas of South Africa. In this South African study, a total of 11,000 children aged 6-71months old from Gauteng and the Limpopo province were enrolled. The results of the study showed that prevalence of stunting in Gauteng province was 11.5% and 34% in rural Limpopo province. According to the results of the study, one in four children in South Africa were stunted showing that stunting is a serious problem in the country.[10]

These findings were consistent with the results from a 1999 study conducted by the National Food Consumption Survey, conducted in 1996, to determine prevalence of malnutrition and anthropometric measures of children aged one to nine years old. The original sample had 3120 children, and the response rate was 93%. The data showed that at a national level in South Africa, one in five children were stunted. The prevalence of stunting was higher in rural areas than in urban areas. In the urban areas 17% of the children were stunted, however, those living in informal settlements exhibited higher rates than those living in formal urban areas, at 20% and 16%

respectively. At a national level one in ten South African children were underweight.[11]

In 2003, another South African study was carried out in Kwa-Zulu Natal (KZN), and nationally to establish the prevalence of stunting, overweight, and obesity amongst 802 children (primary data source) from Vulamehlo district in KZN and 24 391 from a secondary data source. The result showed mild stunting and moderate stunting at 31.4 to 75% and 2.9 to 40% respectively. Severe stunting was reported at 4.9% nationally, 4.5% provincially in KZN and 0.6 % at Vulamehlo district.[12] Findings in this study showed high levels of mild stunting.

In South Africa, stunting is said to be the most common form of malnutrition. Eastern Cape and Northern Cape provinces, which are the poorest regions in South Africa, are reported to have the highest rates of stunted children under the age of five years old.[13-14] This shows a relationship between SES and health and nutrition of which growth is a very good marker thereof.

The South African Report on Physical Activity for children and youth assigned a low grade of D (minus) for stunting in South Africa. This means that stunting needs to be addressed as it poses increased risk of disease to the affected individuals. Obesity and stunting are said to co-exist in South Africa, and this is attributed to poor nutrition in early years. In this study results showed that 30% of adolescent girls and 10% of adolescent boys were obese and 19% were stunted. The co-existence of stunting and obesity doubles the risk to diseases in children, and under-nutrition in early years of life has detrimental effects in later life.[15]

According to a study published by the Lancet (2008), children who are stunted suffer from various setbacks in life, for example, it has been shown that they do not proceed to higher levels of education and that affects their future earning potential. The problem has been shown to perpetuate to the future generations and becomes a repetitive cycle. Children who are undernourished are more likely to become short as adults, achieve lower education levels and give birth to infants who are stunted[3]. Therefore, poor child development has economic implications as stunted children are less likely to be productive as adults[5].

The plight of stunted children is of great concern as it has been shown that consequences of maternal and child under-nutrition are long-term and intergenerational spanning over at least three generations. A population that is stunted has a reduced human potential and this curtails their competitiveness in the modern world.[3] It therefore makes economic sense to address under-nutrition especially during pregnancy and the first 2 years of a child's life.

1.3 Justification for the study

There is a paucity of data in the LMICs looking at the impact of stunting on children's education performance. There is no South African study to date that has assessed the association between stunting and education performance at the end of primary school. This data is needed to inform decisions by the government relating to under-nutrition and its relation to stunting and education performance of children.

Grantham-McGregor et al. (2007) posit that a nurturing environment that offers sufficient stimulation and adequate nutrition for children is what is required to allow them an opportunity to function at their optimum[2]. Malnourished children are at risk of having learning and behavioural problems. They are prone to attention disorders; tend to be impulsive and less capable of adapting to stressful situations. These may be component causes of poor school performance.[16]

Children in South Africa still suffer from early under-nutrition resulting in increased rates of stunting[8,17]. As a developing nations this an issue that needs immediate attention because, according to Grantham-McGregor et al. (2007)[2], children from developing countries who are disadvantaged and who do not reach their developmental potential are less likely to be productive as adults, as studies have found that economic implications for stunted children who do not reach their developmental potential are bleak. The best predictor of future capital is a child's height-for-age at 2 years old[5]. In addition; under-nutrition influences the health, growth, education and development of individuals and nations[5]. The prevailing lack of stimulation among children is interpreted as a loss of potential[2].

1.4 Literature review

1.4.1 Effects of Malnutrition in the physical development of a foetus and infant

1.4.1.1 Maternal Nutrition during Pregnancy

Figure 1.2 below depicts a conceptual framework of insufficient food intake and its ramifications.

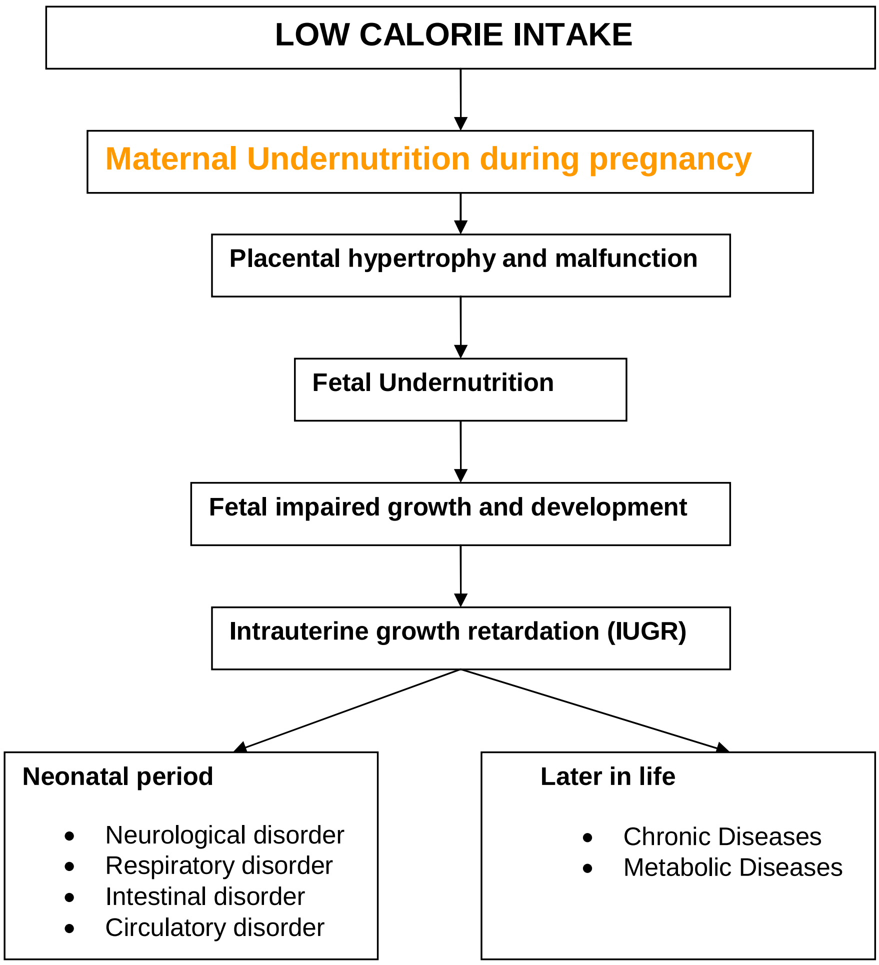

Figure 1.2 Conceptual Framework of maternal Under-nutrition and its impact on foetal and child development

Maternal nutrition during pregnancy is crucial for the optimal healthy development of the foetus. Human and animal studies have shown that the growth rate of a foetus is dependent on the amount of nutrients consumed by the mother and the quantity transferred via the placenta to the foetus[18,19,20]. As such, a malfunction of the placenta may result in foetal under-nutrition[20]. Additionally, the period and length of time of foetal under-nutrition is critical for the foetal outcomes[19,21]. When animals such as rats are exposed to under-nutrition very early in life; that is just after birth, the effects are much more dire and lasting than if the imposition occurred when they are much older [19.]

De Onis (2001) states that foetuses that do not grow to their full potential are more likely to suffer from perinatal morbidity and mortality and are at higher risk of "poor cognitive development and neurological impairment during childhood" [22].

It is important that the nutritional status of a woman is good before and during pregnancy to ensure that she gives birth to a health baby[23,24]. The risks associated with delivering by caesarean section are higher for short women[4]. In a meta-analysis study conducted by the WHO, it was found that the need for assistance during delivery is 60% higher in women who are short in stature compared to their taller counterparts; the definition of short stature depends on woman's country of origin.[25] In addition to maternal short stature, maternal nutrition before and during pregnancy is one of the determinants of IUGR[22].

Furthermore, full term babies who are born with low birth weight are likely to have had intrauterine growth restriction. IUGR is prevalent in 10.8% of live births annually in developing countries. Sixty percent of neonatal deaths are caused by foetal underdevelopment leading to birth asphyxia and infections.[5]

After the baby is born, maternal nutrition is still very important for breastfeeding mothers.

1.4.1.2 Breast feeding

Findings from the Boyd-Orr cohort study conducted in pre-war Britain from 1937 to 1939 showed that there is a strong association between breastfeeding and childhood growth in leg height and these findings were also consistent in adulthood[26]. Out of 4999 children included in the original Boyd-Orr cohort study childhood anthropometric measures were available for 2995 study participants. Measures were taken for leg and trunk lengths only for children between ages 2 and 14 years old. The study participants were contacted again between 1997 and 1998 and adult height measures were collected using a follow up self reporting method using prepared questionnaires [26].

Locally, a South African study assessing the preliminary food-based guidelines (PFBG) for infants aged 6-12 months old showed that prolonged breastfeeding is the least adhered to proposed guideline by the mothers[27]. Other PFBGs included were enjoying time with the baby, introducing small amounts of solids to the baby from 6 months old, gradually increasing the meals of the baby to five times per day, giving the baby clean and safe water frequently, teaching the baby to use a cup for drinking and taking the baby to the clinic monthly [27]. Findings also showed that mothers in the rural areas have a much better appreciation of the benefits of prolonged breastfeeding than those in the urban areas [27].

Breastfeeding is also associated with reduced risk of sudden infant death syndrome (SIDS) and a relative risk reduction in infectious morbidity and mortality in children who were exclusively breastfed for longer durations[28,29]. It is estimated that 1.4 million child deaths in children under the age of 5 years are due to sub-optimum breastfeeding practices.[5]

It is therefore advised that mothers should solely breastfeed their babies during the first six months of life and carry on breast feeding until they are 2 years old. Exclusive breastfeeding in the first 2 months is carried out only in 47-57% of children in Africa, Asia, Latin America and the Caribbean. This percentage decreases after 2 months, at 2-5 months only 25-31% children are exclusively breastfed. When children are 6-11 months old, 6% of mothers in Africa, 10% in Asia, and 32% in Latin America and the Caribbean have ceased breastfeeding. Only 1% of child death is attributed to under-nutrition in countries other than Africa, Asia and Latin America.[5]

In cases of severe malnutrition, maternal supplementation with micronutrients such as vitamin A increases the quantity available in the breast milk thus improving the nutritional status of the infant[5].

As infants grow older, their feeding needs to be complemented and good nutrition is still vital at this stage. WHO guidelines for complementary feeding recommend that whenever possible children should be breastfed exclusively for at least six months.

However, at six months adequately nutritious complementary feeding may be introduced in addition to continued breastfeeding up to the age of two years and beyond [30].

1.4.1.3 Complimentary Feeding

It is crucial that complementary feeding introduced after the recommended six months of exclusive breastfeeding is sufficient and rich in nutrients[5]. According to the WHO faulty complementary feeding practises, diet with insufficient nutrients, and contaminated foods are the main causes of under-nutrition in children. In addition, putting in cereals to bottles of milk for infants as young as two or three is a risk factor for malnutrition[31]. In South Africa some mothers introduce complementary foods as early as 2-4 months old because they believe that the breast milk is "salty milk", "weak milk", and inadequate to meet the needs of the baby [27]. Study showed that complementary solids given to most children are high in vegetables; followed by cereal such as maize-meal porridge - but highly deficient in protein [27]. Diets high in carbohydrates and low in protein have been associated with stunting in South African children [32].

As mentioned earlier, with good nutrition in the first 2 years of a child's life stunting can be prevented. In a study conducted in a rural area in Bangladesh it was found that poor complementary diet and infectious diseases equally influenced stunting[34].

1.4.1.4 Post weaning

After 24 months children can be weaned off the breast milk[30]. Post-weaning five small meals a day comprised of starch, vegetables, fruits, protein, milk and water are recommended[33]. In addition, in order to ensure that children get sufficient nutrients the guidelines are designed to help combat growing nutrition-related communicable diseases which have shown an upsurge in the South African society[33].

1.4.2 Cognitive Development and School Performance

The conceptual study framework adopted for this study is shown in Figure 1.3 and illustrates an association between growth at age 2 years and school performance with socio-economic status, birth weight and maternal education as possible confounders. We hypothesise that physical growth retardation due to under-nutrition affects cognitive development of a child resulting in poor school performance at adolescence. Age at grade 7 which is influenced by the number of times a child repeated a grade is a marker of primary school performance. We hypothesise that children who are older than their counterparts at grade 7 will exhibit poor school performance because they are slower academically hence repeated grade or grades.

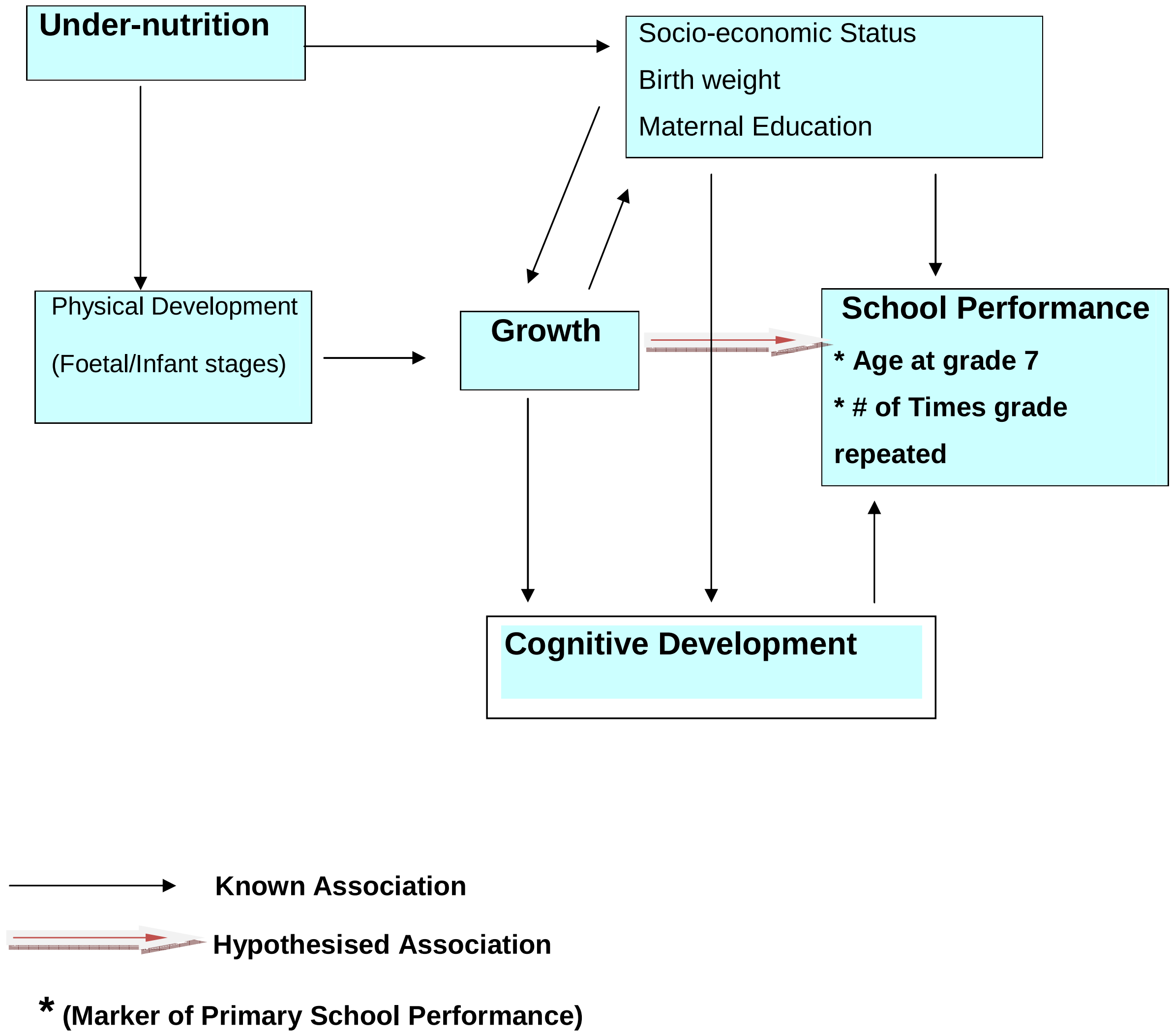

Figure 1.3 Conceptual study framework of association between growth and school performance

Literature reviewed showed that stunting in the first 2 years of life is related to lower school achievement. For example, a study conducted in Jamaica involving children who were stunted at 9 to 24 months old and had participated in a 2-year intervention programme involving psychosocial stimulation with or without nutritional supplementation were re-evaluated at age 11-12 years old. The purpose of the study was to examine the effects of stunting on a child's behaviour and found that stunted children faired significantly lower in arithmetic, word spelling and reading comprehension than non-stunted children irrespective of their social background.[35]

Additionally, a longitudinal study from the Philippines where anthropometric and dietary data were collected twice a month on more than 2000 children during the first years of their lives and followed up when the children were 8 and 11 years old. Findings from the study showed that children who are stunted between birth and 2 years of age scored lower in tests of cognitive ability compared to children who are not stunted[1].

Richards et al. (2002) investigated the association between cognitive function and birth-weight in a British 1946 birth cohort initially comprised of 5362 children. The children were from farming and non-farming families. Cognitive measures were taken for reading comprehension, word pronunciation, vocabulary and non-verbal reasoning; verbal and non-verbal intelligence, reading comprehension and arithmetic; reading comprehension; and verbal memory at the ages 8, 15, 26 and 43 years old respectively. The follow up process took place in 1999 when the study participants were 53 years old and the sample size had reduced to 3035. Height was adjusted for weight at various stages, and possible confounders such as maternal education and socio-economic-status were controlled for. The unadjusted results showed a significant and positive association between height and cognitive development at all ages and a positive association between birth-weight and cognition at ages 8 through 26[36]. However, at age 26 years the association between height and cognition was larger and stronger even after adjustment for adult height[36].

In a house-to-house survey in Kingston, Jamaica, 129 stunted children were identified from a poor neighbourhood and randomised into four arms: control, supplementation, stimulation, or both interventions. The controls were not stunted and came from wealthier neighbourhoods. Their ages ranged between 9 months and 24 months and they were followed until they were 17 years old. Children who were stunted in the first 2 years of their lives exhibited poorer psychological functioning and lower IQ levels compared to the children who were not stunted at age 17 years.[37] Supplementation was shown to have a positive growth effect in stunted children, however, non-stunted children were shown to be taller than their stunted counterparts even after supplementation[38].

Therefore, we can agree with other researchers such as, Stoch et al. (1963) and Walker et al. (2007)[37,38] that an association between growth retardation in children and cognitive development is well established. As such, studies like this one are necessary to further examine the association between early growth and cognitive development later in a child's life development.

1.4.3 Association between growth, cognitive development and school performance

1.4.3.1 Historical Associations

More than five decades ago studies found an association between early growth and cognitive development. In 1955 Stoch and Smythe were the first people to hypothesise that under-nutrition during the first 2 years of a child's life could retard growth which may in-turn inhibit brain growth to its potential size and intellectual capability permanently.[38]

A landmark study was conducted from 1955 to 1960 using data collected from severely undernourished infants aged 10-16 months from the Cape Coloureds in South Africa. The study looked at the impact of under-nutrition on brain growth and intellectual development. The results revealed that undernourished children had smaller mean head circumference and lower height and weight in comparison to the well nourished control group. Electroencephalographic recording used to measure brain growth revealed increased instability on provocation compared to the control group. Eight of the malnourished participants showed slow activity and lack of alpha patterns, a sign of delayed maturation. In classroom educational placement tests the malnourished group performed much poorly compared to their control counterparts.[39]

In 1963, Stoch et al. reported that animal studies that were performed on calves showed that under-nutrition in infancy might limit growth in body size, however, only to a certain extent as growth continues for at least eighteen years. The brain on the other hand terminates growth after the age of 2 years. The researchers[40] then tested the hypothesis that the brain ceases to develop to its full size and intellectual potential due to malnutrition in a comparative longitudinal study involving infants. In the study two groups of infants from similar economic backgrounds were matched. One group was malnourished and the other group was effectively nourished. The groups were matched on sex and age. The infants were followed for seven years. Head circumference and I.Q. were used as indicators for growth in the study. The results showed that the head circumferences were smaller in the malnourished infants and their I.Qs were lower compared to the control group.[40]

Child nutrition is as crucial at conception as it is after a child is born.

1.4.3.2 Effects of under-nutrition in-utero: A biological perspective

As early as the 1920s, it was discovered that there are “critical periods of development” in a baby’s life[41]. According to the concept called ‘Programming the baby, also called foetal programming’, under-nutrition affects the foetus resulting in permanent physiological and metabolic changes during late gestations[42]. ‘Programming’ explains a procedure “whereby a stimulus or, insult, at a sensitive and critical period of development” can have irreversible consequences. Barker defines ‘Programming’ as an important period during which the system is “plastic and sensitive” to the conditions and surroundings that influence our development.[42]

There are several factors that play a role to prevent these “insults”. For example, foetal hormones are necessary for healthy foetal growth, and good nutrition is important for their normal function. They assist in tissue accretion and differentiation. Insulin-like growth hormones work with the foetal hormones to enhance normal growth during late gestations.[43] Berger states that it has been shown that the endocrine profile of stunted babies is distorted, showing low levels of insulin, insulin-like growth factor1, thyroid-stimulating hormone (which affects tissue accretion), and cortisol (which affects tissue differentiation).[44]

The first two months during the embryonic period are responsible for differentiation and, very little growth takes place[42]. The highest levels of growth are attained during the foetal period. Thereafter, it slows down during late gestation and childhood. Under-nutrition modifies the body proportions of animals and this is related to its "growth trajectory". Nutrients and oxygen play a vital role in-utero, they regulate growth of an embryo. It is reported that the "growth trajectory" of males is much faster than that of females during the early stages of embryonic development in humans. This then means that under-nutrition affects boys more than it does girls.[42]

As much as there is some difference in expected growth outcomes for small-for-gestational (SFG) age babies and very low birth weight (VLBW) babies the preceding discussions are somewhat concurred by the results from a cohort study of VLBW babies treated at Rainbow Babies and Children's Hospital in Cleveland, Ohio. The study had 103 male and 92 female infants who had VLBW. They were compared to 101 male and 107 females of normal birth weight (NBW). From age 8 to 20 years old it was observed that the VLBW females had experienced catch-up growth in weight, height and BMI, however, the VLBW males were still smaller than their NBW counterparts. The results also showed higher rates of re-hospitalization amongst the VLBW males compared to females.[45]

After two months, cell replication is the cause of the high levels of growth during the foetal stage. It decreases as the foetus grows older[42]. It is reported that after 30 weeks of gestation there are less new nerve and muscle cells seen[46]. Winick et al., argue that after the period of rapid cell division has stopped cell division cannot begin again[47].

Lucas suggests that under-nutrition during early development could permanently decrease the number of cells[48]. It is said that the number of cells in the organs of humans is directly proportional to their body size and that stunted children have a decreased number of cells which is thought to influence certain functional limitations[42].

Barker also argues that under-nutrition affects the body differently during different stages of gestation. In early gestation, it affects the body size and in late gestation it distorts the body form. As such, if a baby is small but is proportionate it is understood that the baby was undernourished in early gestation and if the baby is disproportionate, then under-nutrition occurred in late gestation.[42]

Studies conducted in recent times agree with previously mentioned findings that took place more than five decades ago, regarding growth and cognitive development.

1.4.3.3 Contemporary perspective

There is significant evidence that associates stunting to cognitive development and school performance, mainly from underdeveloped and developing countries[1,38,49,50,51,52,53,54,55,56,57]. It is reported that school progress in young children is highly dependent on early cognitive and social-emotional development[2].

This association can be explained by an argument made by Shonkoff et al. in 2000, in saying that early years of life are the formative years and they are both "robust and vulnerable". The universal interval for intervention is from pregnancy to the age of 2 years. The damage caused during these formative years is irreversible and predicts the child's future development towards adulthood[58].

In addition, according to an American study conducted by Lewit, et al (1997)[13], when the child is not getting enough food to eat, the child's body switches to a survival mode. First, the body limits social activity and cognitive development to conserve energy, and then it restricts the use of energy available for growth. If starvation persists the child becomes stunted. This is different from short stature which is the result of a genetic influence and is not associated with under-nutrition. Stunting is defined as "having a height (or length)-for-age more than 2SD below the median[6]

The irreversible damage due to poor foetal development includes shorter adult height, lower education achievement, and reduced earning ability in adulthood, and shorter women tend to give birth to offspring who are also short[9].

Recent studies published by the Lancet Series looked at maternal and child under-nutrition. The study showed that millions of children globally suffer from effects of under-nutrition including 13 million suffering from intrauterine growth restriction (resulting in low birth weight) and 178 million children suffering from stunting.[5]

The first paper of the Lancet Series notes that psychosocial and biological factors and, genes influence the development of the child. The reason why the first two years of life are critical in child development is because is it the period when crucial and most important growth takes place in all spheres. Malnutrition and under-nutrition negatively affects the mother and the economical outlook of next generation. There is a lack of literature in developing countries that investigate the outcomes of poor child development[2].

The second paper of the Lancet Series on Maternal and Under-nutrition examines and reports on the effects of stunting in the first 2 years of a child's life in later life. Children who are stunted in the first 2 years of their lives are at high risk of nutrition related diseases. If they gain weight quickly later in childhood, they become susceptible to hypertension and increased levels of cholesterol. However, this does not apply to the fast weight and height gain in the first 2 years.[9]

On the contrary, Theron et al.(2006) conducted a study using adapted, tested, and standardised quantitative food-frequency to measure dietary intake and assess the influence of poor diet on stunted children in urban and rural areas, and their non-stunted control counterparts in South Africa. The results of the study did not show any difference in dietary patterns of both stunted and non-stunted children. The diets for both groups were found to be poor, high in carbohydrates and low fat. As such, the authors suggest that issues such as the quality of food, the manner in which food is prepared, frequency of meals and in young children the length of time a child is breastfed should be considered very closely.[59]

The authors of the fourth paper of the Lancet Series suggest that the first Millennium Development Goal (MDG) 1 can be achieved in low and middle-income countries by "intensified nutrition action"[9]. The first MDG is to "eradicate extreme poverty and hunger", by reducing the number of people who live on less than $1 per day and suffer from hunger by half[60].

The Lancet series authors do acknowledge the fact that strides for intervention have been made by some countries but argue that they do not seem to reach the mothers and children who are undernourished[9].

1.4.3.4 A South African Perspective

A large number of South African children are affected by malnutrition. [61] In 1995 the Department of Health initiated the Integrated Nutrition Programme. The main purpose of the programme is to prevent and manage malnutrition amongst all South Africans and ensure best nutrition for all. In order to reduce micronutrient deficiencies, programs such as supplementation, food fortification, dietary diversification and modification amongst other were introduced.[62]

1.5.4 Mediating factors (Potential Confounders)

The variables selected as possible confounders were selected by using the definition of a confounder which states that "A confounder is a variable that is associated with the exposure of interest (but not caused by the exposure of interest) and that is an independent risk factor for the outcome".[63]

1.4.4.1 Birth weight

In developing countries like South Africa, children who are small at birth are at risk of stunting during infancy. Stunting is reckoned to be the result of inadequate health and nutrition if infancy[8]. Studies have shown that there is an association between low birth weight and under-nutrition[5]. In South Asia, data from the Demography Health Survey showed a relationship between women's economic status and the weight-for-age of their children[64].

1.4.4.2 Maternal education

Data from the 1986 Brazilian Demographic and Health Survey confirmed that parental education is strongly associated with positive child growth indicated by height. Data analysis showed that educated mother were able to access information in the form of reading newspapers, watching television and listening to radio; therefore more informed, which explains why maternal education has such an impact.[65]

Education affords mothers an ability to make more informed decisions regarding healthy behaviour during pregnancy. Educated mothers are better equipped to synthesize and absorb available health information than others[66].

1.4.4.3 Socio-economic status

In South Africa, stunting is most prevalent in the Eastern Cape and the Northern Province. These two provinces are noted for their high levels of poverty. Living Standards and Development Survey collected data on 3765 children under the age of five years. The main indicator used for socioeconomic status was household income, "proxies by per capita household expenditure". Illness concentration index was used to measure socio-economic inequality in malnutrition. In this South African study, stunting and underweight was significantly lower in more affluent households.[67]

1.5 Definition of terms

WHO 2006 growth standards were utilized to generate z-scores for length-for-age, weight-for-age, weight-for-height and BMI-for-age; at age 2 years.

1.5.1 Stunting (exposure variable)

Stunting is defined as a chronic restriction of growth in height indicated by a low length-for-age generally which is less than -2SD in z-score for height-for-age.

1.5.2 Education performance (outcome variable)

In this study education performance is academic achievement using score for Mathematics and English (or the child's first language) at final year of primary school (grade 7).

1.6 STUDY AIM AND OBJECTIVES

The aim of this study is to investigate the association between growth at age 2 years and school performance of adolescents at grade 7. As a secondary objective, other exposure growth variables such as weight-for-age; weight-for-height and BMI-for-age were also investigated for the association.

1.6.1 Specific objectives

1. To describe growth at age 2 within this cohort for length-for-age, weight-for-age, weight-for-height and BMI-for-age as stated by the WHO 2006 growth standards. In addition, to describe the prevalence of stunting, wasting and overweight at age 2 years.

2. To describe the distribution of socio-demographic factors stratified by gender.

3. To describe the prevalence low birth weight and the prevalence of stunting, underweight, wasting and obesity at age 2 years.

4. To describe school performance at grade 7 in Mathematics and English or first language, and to define school performance in terms of grades repeated and age at grade 7.

5. To determine the association between height at age 2 years and education performance in Mathematics and English or first language at the end of primary school adjusting for possible confounders such as birth weight, maternal education and SES.

CHAPTER TWO

2.0 MATERIALS AND METHODS

2.1 Sample and sampling characteristics

2.1.1 Methodology

BT20 is a longitudinal cohort study that was conceptualised to investigate effects of the urbanization of black South Africans (in the late 1980's) on the development and growth of children. Initially, the intention was to follow a group of children for ten years, as such, the study was called Birth to Ten (BT10). After reaching the 10-year goal, the study was extended to twenty years thus, Birth to Twenty (BT20).

The children in the study were born 7 weeks subsequent to former president Nelson Mandela's release from prison, making them the first cohort born into the free South Africa. As such, they are affectionately called the "Mandela's Children"[68].

As depicted in Figure 2.1 study participants included in the in cohort were singletons born in a specified 7-week (April 23 to June 8, 1990) and had to reside in the Johannesburg metropolitan area for at least 6 months after the birth of the child. The Johannesburg metropolitan area included "the extant town councils governing Johannesburg, Soweto and Diepmeadow". Its population size was about 3.5 million with about 11.4% residing in informal housing settlements[69].

Pilot studies were undertaken to establish the best time of the year and means to conduct the study in the area[68].

Data was collected by interviewers who were strategically placed in all public delivery health centres during the enrolment period. They also checked birth notification and mortuary records, and followed-up those women who attended postnatal health services[69].

At the end of the enrolment period, 3273 children were recruited into the study. The levels of attrition have been significantly low for a longitudinal study. In the first 12 years of the study the average attrition rates were below 3% per annum. Most of the attrition took place in the first 2 years of the study mainly due to mother or child death and other various reasons. Other reasons for attrition varied from people moving between rural and urban areas, to some moving from one place to the other, in addition, lack of street names and numbers in the participant's residing areas, can complicate matters .[69]

Overall, the cohort comprised of 78% Africans, 6% Whites, 12% Coloureds and 4% Indians. The age range for most mothers was 20-38 years old (82%), 17-19 years old (12%) and only 6% either were below 17 years or above 39 years old. 57% had had between 2-4 pregnancies and 85% carried their babies to term at 37-41 weeks. The majority (86%) of the babies in the cohort had a normal birth weight of 2500-3999 grams.

2.2 Study sample size

In the current study, the sample size was reduced to 600 because only study participants who had data for Mathematics and English for first language (outcome variable) could be included. The sample was further reduced to 252 due to missing data for the exposure variables such as height, weight and BMI at age 2 years.

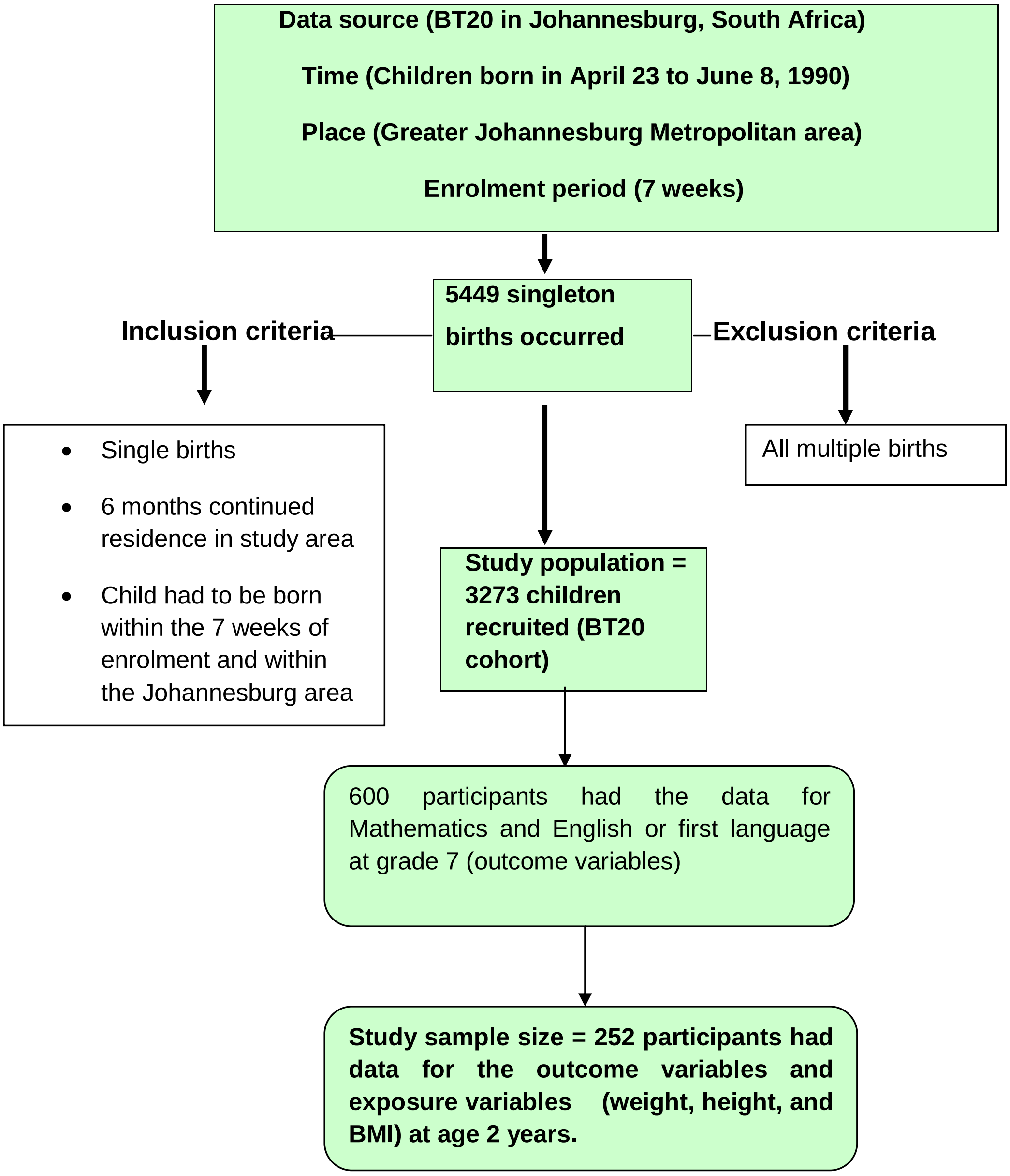

Figure 2.1 Study population and our study sample size

Data was analysed to check for systematic bias. The key demographic characteristics of participants excluded from analysis (that is participants with no data for Mathematics and English or first language at grade 7) and missing data for height at age 2 years and those included in the analysis (participants with grade 7 Mathematics and English or first language scores and data for height at age 2 years). As shown in Table 2.1 below, the demographic distribution between the two groups was similar, however, only population group and birth weight were statistically significant. Overall, we concluded that systemic bias was not introduced during the selection of the study sample (n=252).

Table 2.1 Demographic Characteristics of excluded BT20 cohort study participants **(n=3273-252=3021)** versus study-sample **(n=252)**

Characteristics		**Bt20 participants excluded from Analysis** Total (%)	**Study Sample** Total (%)
Population group $\chi_{(3)}^2 = 3.776$, NS, n=2122	African	1564 (83.59)	219 (87.27)
	White	64 (3.42)	10 (3.98)
	Coloured	216 (11.54)	20 (7.97)
	Indian	27 (1.44)	2 (0.80)
Gender $\chi_{(1)}^2 = 2.941$, NS, n=2102	Males	866 (47.35)	103 (41.04)
	Females	985 (52.65)	148 (58.96)
Gravidity $\chi_{(2)}^2 = 2.545$, NS, n=2121	1	668 (35.72)	98 (39.04)
	2-4	1041 (55.68)	138 (54.98)
	≥5	161 (8.6)	15 (5.98)
Residential Area $\chi_{(4)}^2 = 5.337$, NS, n=2121	Soweto/Diepmeadow	1174 (62.78)	155 (61.75)
	Suburban Jhb	374 (20.0)	62 (24.70)
	Former Indian/ Coloured areas	220 (11.76)	21 (8.37)
	Inner city	5 (0.27)	0
	Not known	97 (5.19)	13 (5.18)
Birth weight (g) $***\chi_{(3)}^2 = 222.452, p<0.001$, n = 3245	<1500	20 (0.67)	3 (1.20)
	1500-2499	147 (4.91)	23 (9.16)
	2500-3999	1316 (43.95)	221 (88.05)
	4000+	1511 (50.47)	4 (1.59)

Individual items may not add up to totals because of missing data; **** p < 0.001, ** p < 0.01, * p < 0.05, † p < 0.10*

2.3 Study design

The study design is a nested longitudinal study. It entails primary data analysis of secondary data from the BT20 cohort.

2.4 Study variables

Variables used in the study analysis are described in Table 2.2 below.

Table 2.2 Variable Table

VARIABLE	**DESCRIPTION**
Schooling	
School performance	Academic achievement using score for Mathematics and English (or the child's first language) at grade7.
School reports	Grade 7 school report.
Repeats	Number of times pupil repeated a grade.
Age	Age of study participants at grade 7.
Measures of growth at age 2 years	
Height (stunting)	A chronic restriction of growth in height indicated by a low height-for-age generally which is less than -2SD in z-score for height-for-age.
Weight	Defined as a z-score of weight-for-age as defined by the WHO 2006 growth standards. A Z-score cut-off point of <-2SD is used to classify low weight-for-age.
BMI	Defined as a z-score of BMI-for-age as defined by the WHO 2006 growth standards.
Wasting	Defined as a z-score of weight-for-height as defined by the WHO 2006 growth standards. A Z-score cut-off point of <-SD is used to classify low weight-for-height. A Z-score cut-off point >+2SD was used to classify high weight-for-height as overweight and as overweight
Possible confounders	
Birth weight	Child's weight at birth. Low birth weight defined as birth weight below 2500g and very low birth

	weight as birth weight below 1500g.
Maternal education	Level of education attained by child's birth mother.
Household Socio-economic status	House hold assets: house type, ownership of home, toilet type, and water sources, scores used as indicators for socio-economic status.

2.4.1 The exposure variable: Measure of growth (stunting) at 2 years old

Stunting is defined as a z-score of length-for-age using WHO references of -2SD[5]. Data collected when children were 2 years old was used to investigate the association with school results at grade 7.

2.4.2 Other exposure variables

2.4.2.1 Low Birth Weight

Low Birth weight is defined as weight below 1000g.

2.4.2.2 Measure of weight at age 2 years

Overweight is defined as a z-score of weight-for-age and weight-for-height as defined by the WHO 2006 growth standards[5].

2.4.2.3 Measure of wasting (weight-for-height) at age 2 years

Wasting is defined as a z-score of height-for-weight as defined by the WHO 2006 growth standards[6].

2.4.2.4 Measure of BMI-for-age at age 2 years

Obesity is defined as a z-score of a BMI-for-age as defined by the WHO 2006 growth standards.

2.4.3 The outcome variable: Measure of school performance at grade 7

School reports are collected every year for all the study participants. School reports from 2002/2003 focusing on grade 7 results (the last year of primary school) were utilized. The final grade 7 school reports were selected, if it was not available a 3rd term report, then a 2nd report, then a 1st term report was selected.

School performance was defined as a score of Mathematics and English (or the child's first language) at grade 7.

Different schools had different grading systems such as numerical scores, percentages and symbols. The outcome variable was recoded into 3 categories. The categories were high achievement category comprised of participants who achieved a score of +70%; average achievement category was made up of participants who achieved a score of 40%-69% and low achievement category with participants who achieved a score of <40%. Table 2.3 below summarises how the marking system in the study was converted for all the different grading systems.

Table 2.3 Marking System

Coding system	**Percentage**	**Symbol**	**Grading**	**OBE**
1	80 - 100	A	Very Good	Excellent
2	70 – 79	B	Good	Achieved
3	60 – 69	C	Average	Almost competent
4	50 – 59	D	Below average	Not yet competent
5	40 – 49	E	Weak	
6	30 – 39	F	Fail	
7	<= 30	<= G		

2.4.3.1 Recoding of Mathematics and English or first language scores for grade 7 (outcome variable)

Mathematics and English or first language scores for grade 7 were recoded into three categories as shown in Table 2.4.

Table 2.4 Recoding of Mathematics and English scores for grade 7

Low Achievement =1	< 40%
Average Achievement =2	40 -69%
High Achievement =3	+70%

2.4.4 Markers of School Performance

i. Age at grade 7, that is, the age of the study participants at grade 7.

ii. Number of times the study participant repeated the grade. Grade repeats distinguishes those participants who had not repeated a grade to those participants who had repeated a grade at least once or more times during the course of their schooling.

2.4.5 Potential Confounders

In Table 2.5 coding system used in STATA and data collection methods for birth weight and potential confounders are tabulated.

Table 2.5 Birth weight and potential confounders

Factor	**Coding**	**Method used for data collection**
Birth weight (g) <1500 1500-2499 2500-3999 4000+	 1 2 3 4	Data for birth weight was collected from clinic or hospital cards.
Maternal Education None Primary Secondary Higher Education	 0 1 2 3	Data was collected through interviews by the trained research assistants using questionnaires.
		Field workers visited the homes of the participants. House hold assets and facilities listed below were used as indicators for socio-economic status.
House type House Other	 1 0	
Have own house Yes No	 1 0	
Factor	**Coding**	**Method of collection**
Water type Running indoors Running outdoor	 1 0	
Water use Sole use Shared use	 1 0	
Toilet use Indoors Outdoors	 1 0	
Toilet type Flush indoors / outdoors Bucket system / other	 1 0	

Have electricity Yes No	 1 0	
Have television Yes No	 1 0	
Have motor vehicle Yes No	 1 0	
Have refrigerator Yes No	 1 0	
Have washing machine Yes No	 1 0	
Have telephone Yes No	 1 0	

2.5 Data processing methods and data analysis

2.5.1 Data collection

Mathematics and English or first language scores were collected from grade 7 school reports of the study participants. Methods of data collection for birth weight and possible confounders are described in Table 2.5. Data for weight, height and BMI at age two years was collected from clinic and hospital cards.

2.5.2 Data Processing methods

Data was analyzed using Microsoft excel and STATA version 10. Preliminary analysis was conducted to clean the data. Data was cross-checked to ascertain if there were any discrepancies between the electronic data and the original data as recorded in the participant's files.

2.5.2.1 Step 1: Cleaning and checking the data

The school report data base which included school reports for all grades was checked for any discrepancies between electronic and paper data. Then, a 5% random sample was extracted to determine if there were any discrepancies between the electronic captured data and the data as documented in the actual school reports of the study participants. A sample of 212 hard copies of school reports (451 reports) inclusive of all grades was drawn out.

The results showed that of the 451 reports checked, 27.05% of the data had not been captured electronically. Almost 25% of the captured data was missing on paper. (Appendices, Table A1) In addition, 70.07% of the data that was not captured electronically did not exist on paper as well, 19.00% was not captured electronically but existed on paper and10.93% was captured and could not found in the files.

The first sample, tabulated in Table A1, (which included all grades) was further reduced to include grade 7 reports only (Appendices, Table: A2). A total of 42 hard copies of school reports were checked. Again, the data was analyzed for variation between electronic and paper data. The results showed very little variation compared to the rest of the data. Of the 42 school reports checked, 4 cases did not have electronic data (3 of which related to three school terms that were not entered electronically for and the other one case was whereby there was no report on file and as such no electronic report as well). The other case was captured electronically but the documents were not on file. (Appendices, Table: A2).

2.5.2.2 Step 2: Cleaning and checking the data

A new random sample was taken (5%) to analyze differences in electronic and paper data in grade 7 reports only (Appendices, Tables: A3). Fourty five reports were examined. Almost 90% of the electronic and paper data were the same. Data was checked to determine the common error between the data captured electronically and paper data. There were very few errors relating to the school marks which included missing grade 1 report, grade not indicated in reports or grades not captured electronically. (Appendices, Tables: A3 & A4)

2.5.2.3 Step 3: Data Cleaning and checking

In figure 2.3, the sample was drawn to determine how many of the 3273 BT20 participants had the data for (outcome variable) grade 7 results for Mathematics and first language. The results showed that there were 1,975 school reports in total of which, 770 reports were for grade 7. Duplicate reports for grade 7 were dropped, reducing the sample size to 600 grade 7 reports. The sample size was further reduced to 252 because of missing data for height, weight, and BMI data at age 2 years.

Of the 1,975 school reports identified only 770 were grade 7 school reports. The results for the distribution of grade 7 reports per term are tabulated in Table 2.6. Frequency represents the distribution of school reports by term. The largest proportion of school reports in the sample were final term reports (term 4).

Table 2.6 The distribution per school term for grade 7 results

Term	Frequency	Relative Frequency
1	173	22.47%
2	231	30.0%
3	101	13.12%
4	265	34.42%
Total	770	100.0%

Some of the study participants had school reports for more than one term resulting in duplication. Therefore, data was analysed to remove duplicate school reports.

Table 2.7 represents a distribution of grade 7 school reports. They were distributed as follows: 540 reports had only one term (which could be any one of the four terms), 38 reports had two terms, 14 reports had three terms, five reports had four terms, two reports had five terms (one term must have been entered more than once), and one report had seven terms (again, some terms must have been entered more than once).

Table 2.7 Distribution of grade 7 school reports

Number of reports	Frequency	Relative frequency	Cumulative relative frequency
1	540	90.00%	90.00%
2	38	6.33%	96.33%
3	14	2.33%	98.67%
4	5	0.83%	99.50
5	2	0.33%	99.83%
7	1	0.17%	100.00%
Total	600	100.00	

The sample size was further reduced to 252 because there was data missing for height, weight and BMI at age 2 years as illustrated in Figure 2.4.

2.5.3 Classification of first language

The random sample showed that various languages were classified as the first language. We analyzed data for the languages used to define first language in grade 7 reports only. In almost 50% of the cases, English was defined as first language. (Appendices, Table: A5 – sample 1 and sample 2 as depicted in Appendices, Table A2 and A3 respectively)

2.5.4 Data Analysis

2.5.4.1 Descriptive statistics

i. Data was analysed to check for systematic bias.

ii. Demographic variables such as birth weight, height at age 2 years, body mass index at age 2 years, weight-for-age, weight-for-height and age at grade 7 were described by calculating the mean and standard deviation. Maternal education levels were described by calculating frequencies and relative frequencies. All variables were stratified by gender.

iii. Indicators for household socio-economic status such as type of house, ownership of own home, water facilities, water usage, electricity, television, motor vehicle, refrigerator, washing machine and telephone are described by calculating frequency and relative frequency; stratified by gender.

iv. The frequency distribution of scores for Mathematics and English (or first language) were calculated against the demographic variables.

v. Binary logistic regression was used to model grade repetition variable.

2.5.3.2 Inferential Statistics

i. The association between school performance at grade 7 (outcome variable) and height-for-age at age 2 years, weight-for age at age 2 years, weight-for-height at age 2 years and BMI-for-age at age 2 years was explored using logistic regression analysis.

ii. The difference in means for weight-for-age, height-for-age, weight-for height and BMI-for-age was checked using t-tests.

iii. The association between school performance at grade 7 and potential confounders (birth weight, socio-economic status and maternal education) were explored using chi-squared tests.

2.5.3.3 Analytical Statistics

i. We looked at 2 education outcomes (Mathematics, and English or child's first language) categorised into 3 levels as shown in Table 2.3.

ii. Ordinal logistic regression model is used to test for association between school performance at grade 7 and height at age 2 years adjusting for possible confounders.

2.6 Ethical considerations

Ethical clearance for BT20's primary data collection was obtained from University of Witwatersrand Faculty of Health Sciences for Research on Human Subjects (Medical) [6].

Mothers were well educated about what the research entails and if they chose to participate, they voluntarily signed informed consent forms. Data collection was done by trained researchers using a standardised questionnaire.

Permission to use this data was sought from BT20 for secondary analysis.

The protocol for this study was unconditionally approved by the Wits University Postgraduate and Human Research Ethics committees (APPENDIX F).

CHAPTER 3

3.0 Results

This chapter is divided into two parts. The first part presents the descriptive component and comprises the distribution of anthropometric measures utilized in the study, socio-demographic factors of the study participants and prevalence of low birth weight, underweight, wasting and obesity at age 2 years,

The second part presents the analytical component and it examines the association between socio-demographic characteristics and school performance. Graphs and tables are utilized to summarize study results.

3.1 Distribution of birth-weight and other measures of growth

Figure 3.1 shows the distribution of the z-score data for Height-for-Age at two years. The graph demonstrated that data was not normally distributed – showing a much higher proportion of children with a height-for-age below the mean.

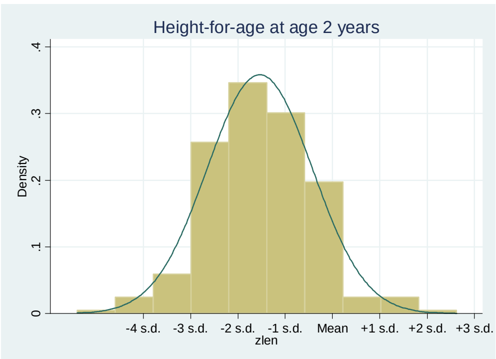

Figure 3.1 Height-for-age

3.2 Descriptive Analysis

In table 3.1 the socio-demographic characteristics of the sample study participants were described and stratified by gender. No significant mean difference in all socio-demographic factors was present between males and females (P>0.05). Overall, the mean birth weight for all study participants was 3103.5g with a standard deviation of 498.5. Mean z-scores and standard deviation were calculated for height-for-age, weight-for-age, weight-for-height and BMI-for-age at age 2 years. The mean z-score for height-for-age at age 2 years was -1.54 (1.11); -0.50 (1.25) for weight-for-age, 0.41 (1.50) for weight-for-height and 0.41 (1.50) for BMI-for-age.

Approximately 76% of mothers had achieved secondary education. A small proportion of participating households lived in formal houses. About 83.5% dwelled in informal settlements such as shacks, hostels, shared house, room, cottage or garage. A large percentage had access to indoor running water, sole water usage, television, refrigerator, and telephone at 73.66%, 87.80%, 86.89%, 79.28%, 73.89%, and 60.56% respectively.

Assets such as electricity, motor vehicle, and washing machine were less accessible with ownership at 3.19%, 28.29% and 15.94% respectively.

Table 3.1 Distribution of socio-demographic factors of study sample (n=252) by gender

Factors		Male Mean Z-score (std) N=103	Female Mean Z-score (std) N=149	Total N=252
Birth weight (g) $t_{(250)}$=0.960, P=0.34, n=252		3139.7(537.32)	3078.4(468.75)	3103.5(498.53)
Height-for-age (z-score) $t_{(250)}$=-1.004, P=0.32, n=252		-1.62 (1.05)	-1.478(1.16)	-1.54 (1.11)
Weight-for-age(z-score) $t_{(250)}$=-0.666, P=0.51, n=252		-0.56 (1.27)	-0.45 (1.23)	-0.50 (1.25)
Weight-for-height (z-score) $t_{(250)}$=-0.338, P=0.74, n=252		0.37(1.53)	0.43 (1.47)	0.41 (1.50)
BMI-for-age (z-score) $t_{(250)}$=-0.063, P=0.95, n=252		0.63 (1.59)	0.65 (1.57)	0.64 (1.58)
# of times repeated a grade $t_{(250)}$=1.713, p=0.09, n=252		0.31(0.56)	0.20(0.45)	0.25 (0.50)
Age at grade 7 (years) $t_{(248)}$=1.870, P=0.06, n=250		13.1(1.36)	12.98 (0.93)	13.0 (1.13)
		N(%)	**N(%)**	**N(%)**
Maternal Education	None/Primary	14 (13.59)	18 (12.16)	32 (12.74)
	Secondary	75 (72.82)	116 (78.38)	191 (76.10)
$\chi^2_{(2)}$ = 1.556, p=0.45, n=248	Higher education	14 (13.59)	14 (9.46)	28 (11.16)
House type	House	15 (14.71)	25 (17.86)	40 (16.53)
$\chi^2_{(1)}$ = 0.4247, p=0.52, n=242	Other	87 (85.29)	115 (82.14)	202 (83.47)

Have own house $\chi_{(1)}^2 = 1.658$, p=0.20, n=250	Yes No	29 (28.16) 74 (71.84)	31 (21.09) 116 (78.91)	60(24.0) 190 (76.0)
		N(%)	**N(%)**	**N(%)**
Water type $\chi_{(1)}^2 = 0.143$, p=0.71, n=205	Running water (hot/cold indoors) Tap/other outdoors	66 (75.01) 22 (25.00)	85 (72.65) 32 (27.35)	151 (73.66) 54 (26.34)
Water use **$\chi_{(1)}^2 = 5.221$, p=0.02, n=205	Sole use Shared use	77 (87.50) 11 (12.50)	103 (88.03) 4 (11.97)	180 (87.80) 25 (12.20)
Have electricity $\chi_{(1)}^2 = 0.274$, p=0.60, n=251	Yes No	4 (3.88) 99 (96.12)	4 (2.70) 144 (97.30)	8 (3.19) 243 (96.81)
Have television $\chi_{(1)}^2 = 0.044$, p=0.83, n=251	Yes No	81 (78.64) 22 (21.36)	118 (79.73) 30 (20.27)	199 (79.28) 52 (20.72)
Have motor vehicle $\chi_{(1)}^2 = 0.370$, p=0.54, n=251	Yes No	27 (26.21) 76 (73.79)	44 (29.73) 104 (70.27)	71 (28.29) 180 (71.71)
Have refrigerator $\chi_{(1)}^2 = 0.448$, p=0.50, n=251	Yes No	77 (74.76) 26 (25.24)	116 (78.38) 32 (21.62)	193 (73.89) 58 (23.11)
Have washing machine $\chi_{(1)}^2 = 0.246$, p=0.62, n=249	Yes No	15 (14.56) 88 (85.44)	25 (16.89) 123 (83.11)	40(15.94) 211 (84.06)
Have telephone $\chi_{(1)}^2 = 0.475$, p=0.49, n=251	Yes No	65 (63.11) 38 (36.89)	87.(58.78) 61 (41.22)	152 (60.56) 99 (39.44)

Individual items may not add up to totals because of missing data

In table 3.2 the prevalence of stunting, low birth weight, underweight, wasting and obesity were tabulated and stratified by gender. Low birth weight is defined as birth weight below 1000g [6]. The results show that overall, 29.13% of the study participants in this cohort had z-score for height at age 2 years below -2SD (defined as stunted in this study). And, the proportion of girls defined as stunted is equal to that of boys. Only 2.36% had a low birth weight and 8.66% were underweight at age 2 years. 5.51% of the children had a low weight-for-height (wasting) and only 1.97% were obese at age 2 years.

Table 3.2 Data for study growth variables below a z-score of -2SD or above a z-score of+2SD (obesity) and birth weight below 1000g (LBW)

Factor	Total (%)	Overall mean z-score(std)	Sex	N (%)	Mean z-score(std)
Stunting	74(29.13)	-2.62(0.61)	Male	37(50.0)	-2.53(0.51)
			Female	37(50.0)	-2.71(0.69)
LBW(g)	6(2.36)	1402.67(715.59)	Male	3(50.0)	1305.33g(1048.46)
			Female	3(50.0)	1500g(390.51)
Underweight	22(8.66)	-2.64(0.70)	Male	9(40.91)	-2.74(0.36)
			Female	13(59.09)	-2.56(0.87)
Wasting	14(5.51)	-2.77(0.99)	Male	6(42.86)	-2.62(0.76)
			Female	8(57.14)	-2.89(1.18)
Obesity	5(1.97)	2.59(0.48)	Male	1(20.0)	2.93(.)
			Female	4(80.0)	2.50(0.51)

Table 3.3 summarized the distribution of socio-demographic factors against school performance. There was a higher percentage of children (30.7%) from families that lived in a house who achieved a low Mathematics score compared to children who did not live in a house (12.6%).($\chi_{(2)}^2$ = 8.7987, P = 0.012, n=237). A greater proportion of children from homes with a motor vehicle achieved a high score for

Mathematics (25.7%) compared to children from homes with no motor vehicle (17.1%) ($\chi_{(2)}^2$ = 8.5082, P=0.014, n = 246).

In the high category for English or first language (language) there were 33.3% females and 16.2% males ($\chi_{(2)}^2$= 18.2613 P = 0.000, n = 243). Almost 27% of the children whose mother's have a higher education level got high scores in language compared to children whose mothers had achieved a primary and secondary education ($\chi_{(2)}^4$= 14.1606, P = 0.007, n=242**)**.

Table 3.3 Gender, growth variables and socio-demographic factors against school performance in Mathematics and First language at grade 7

Socio-economic status factors	School Performance					
	Mathematics score			**First Language score**		
	Low	**Average**	**High**	**Low**	**Average**	**High**
Gender (n;%) Males Females	17 (16.7) 22 (15.2)	69 (67.7) 91 (62.8)	16 (15.7) 32 (22.1)	15 (15.2) 4 (2.8)	68(68.7) 92(63.9)	16(16.2) 48(33.3)
	Pearson chi2(2) = 1.5608 P=0.46, n = 247			**Pearson chi2(2) = 18.2613** **P = 0.000, n = 243**		
Height (cm;std) Overall Males Females	82.7;(3.20) 83.6;(3.00) 81.9;(3.24)	83.1;(3.66) 83.2;(3.23) 83.1;(3.98)	81.9;(3.97) 84.6;(3.82) 80.8;(3.51)	82.3;(2.52) 83.4;(3.18) 80.6;(1.84)	83.3;(4.41) 83.6;(3.28) 82.4;(4.11)	83.2;(4.29) 82.9;(3.51) 82.6;(3.53)
	β = -0.37; std error = 0.392; p=0.34			β = 0.62; std error = 0.37; p=0.71		
Weight (kg;std) Overall Males Females	11.4;(1.58) 11.5;(1.69) 11.4;(1.52)	11.5;(1.77) 11.7;(1.73) 11.3;(1.80)	10.9;(1.19) 11.6;(0.93) 10.7;(1.20)	10.8;(1.16) 11.2;(1.39) 10.9;(1.02)	11.2;(1.66) 11.7;(1.76) 11.4;(1.74)	11.8;(1.62) 11.8;(1.17) 10.9;(1.50)
	β = -257.6; std error = 176.8; p=0.14			β = 88.9; std error = 76.1; p=0.24		
BMI (kg/m^2; std) Overall Males Females	16.8(2.40) 16.4;(2.27) 17.0;(2.52)	16.6(2.27) 16.8;(2.24) 16.4;(2.29)	16.3(1.18) 16.2;(1.50) 16.4;(1.95)	15.9(1.95) 16.1;(1.79) 16.8;(1.55)	16.0(1.67) 16.8;(2.36) 16.8;(2.44)	17.1(2.35) 17.1;(1.21) 15.9;(1.83)
	β = -0.39; std error = 0.29; p=0.18			β = 0.15; std error = 0.12; p=0.20		
	N(%)	**N(%)**	**N(%)**	**N(%)**	**N(%)**	**N(%)**
1.Maternal Education None / Primary Second Higher	8(25.0) 28(15.1) 3(10.7)	19(59.4) 124(66.7) 16 (57.1)	65(15.6) 34(18.3) 9(32.1)	7(21.9) 10(5.5) 2(7.1)	21(65.6) 123(67.6) 15(53.6)	4(12.5) 49(26.9) 11(26.5)
	Pearson chi2(4) = 5.4110, P=0.248, n=246			**Pearson chi2(4) = 14.1606,** **P = 0.007, n=242**		

	N(%)	**N(%)**	**N(%)**	**N(%)**	**N(%)**	**N(%)**
2.Type of house Other House	 25(12.6) 12(30.7)	 135(68.2) 19(48.7)	 38(19.2) 8(20.5)	 15(7.7) 3(7.9)	 132(67.7) 21(55.3)	 48(24.6) 14(36.8)
	Pearson chi2(2) = 8.7987, P = 0.012, n=237			Pearson chi2(2) = 2.5366, P=0.281, n=233		
Have Own-house No Yes	 34(18.6) 5(8.3)	 117(63.2) 41(68.3)	 34(18.4) 14(23.3)	 15(8.2) 4(6.8)	 119(65.4) 39(66.1)	 48(26.4) 16(27.1)
	Pearson chi2(2) =3.6216, P = 0.164, n= 245			Pearson chi2(2) = 0.1336, P=0.935, n=241		
4.Water type Tap/other outdoors Hot/cold indoors	 24(16.1) 9(16.9)	 102(68.5) 32(60.4)	 23(1548) 12(22.6)	 13(9.0) 5(9.3)	 96(66.7) 35(64.8)	 35(24.3) 14(25.9)
	Pearson chi2(2) = 1.5743, P=0.46, n= 202			Pearson chi2(2) =0.0643, P=0.968, n=198		
5.Water usage Shared Sole usage	 7(29.2) 26(14.6)	 13(54.2) 121(67.9)	 4(20.8) 31(17.4)	 4(16.7) 14(8.1)	 15(62.5) 116(66.7)	 5(20.8) 44(25.3)
	Pearson chi2(2) =3.3593, P = 0.186, n = 202			Pearson chi2(2) =1.9486 P=0.377, n = 198		
6. Have electricity No Yes	 2(25.0) 37(15.6)	 6(75.0) 153(64.3)	 0(0.0) 48(20.2)	 1(14.3) 18(7.7)	 5(71.4) 154(65.5)	 1(14.3) 63(26.8)
	Pearson chi2(2) = 2.1872, P = 0.335, n = 246			Pearson chi2(2) = 0.8192, P=0.664, n = 242		
8. Have television No Yes	 10(20.0) 29(14.8)	 27(54.0) 132(67.4)	 13(26.0) 35(17.9)	 6(12.5) 13(6.7)	 32(66.7) 127(65.5)	 10(20.83) 54(27.8)
	Pearson chi2(2) = 3.1323 P=0.209, n = 246			Pearson chi2(2) = 3.1323 P=0.209, n = 246		
9. Have motor vehicle Yes No	 4(5.7) 35(19.9)	 48(68.6) 111(63.1)	 18(25.7) 30(17.1)	 2(2.9) 17(9.9)	 46(65.7) 113(65.7)	 22(31.4) 42(24.4)
	Pearson chi2(2) = 8.5082, P=0.014, n = 246			Pearson chi2(2) = 5.1756 P = 0.075, n = 242		
Have refrigerator						

No Yes	7(12.7) 12(6.4)	35(63.6) 124(66.3)	13(23.6) 51(27.3)	7 (12.7) 13(7.0)	37 (67.3) 127 (67.9)	11(20.0) 47(25.1)
	Pearson chi2(2) =2.4142, P=0.299, n = 243			Pearson chi2(2) = 1.2439, P=1.2439, n = 246		
	N(%)	**N(%)**	**N(%)**	**N(%)**	**N(%)**	**N(%)**
10. Have washing machine No Yes	38(18.5) 1(2.5)	131(63.6) 28(70.0)	37(17.9) 11(27.5)	18(8.9) 1(2.5)	136(67.3) 23(57.5)	48(23.8) 16(40.0)
	Pearson chi2(2) = 7.1475, P=0.028, n = 246			Pearson chi2(2) = 5.5672, P=0.062, n = 242		
11. Have telephone No Yes	22(22.9) 17(11.3)	55(57.3) 104(69.3)	19(19.8) 29(19.3)	9(9.7) 10(6.7)	61(65.6) 98(65.8)	23(24.7) 41(27.5)
	Pearson chi2(2) = 6.2736, P = 0.043, n= 246			Pearson chi2(2) = 0.8099, P=0.667, n = 242		

Individual items may not add up to totals because of missing data

3.3 Analytical Component

The data was analyzed using ordinal logistic regression. The response variables, school performance in Mathematics and English or first language at grade 7, were treated as ordinal under the assumption that the three categories of school performance (low achievement, average achievement and high achievement) have a natural ordering that ranges from low to high.

The outcome variable was measured as high achievement (i.e. high compared to combined average and low, or combined high and average compared to low) versus low given that other variables are held constant in the model. In order to simplify the reporting of the results in the following section; high compared to combined average and low, or combined high and average compared to low will be referred as high achievement and will be compared to the low category.

Possible confounders were adjusted for using forward selection and only statistically significant variables which improved the fit of the model were included in final models. In accordance to the statistician advice, a factor was defined as a confounder if when added to the model it resulted in a 15% or more change of the odds ratio or of the beta coefficient of the z-core for height at age 2 years or other exposure variables. The mathematics and English categories were categorised as high=0 and low=1. Therefore, the high odds ratio is associated with low mathematics and English achievement score.

In Table 3.4 we first examined the data to determine if there is any association between mathematics scores and the socio-economic factors including, gender of the child; birth weight; height-for-age at 2 years; weight-for-age at 2 years; and height-for-weight at age 2 years; and BMI-for-age at 2 years.

The results showed that the adjusted odds of being in the high achievement in Mathematics for girls is 2.1 (P=0.02 and 95% CI 1.11; 4.27) times higher than for boys adjusting for the confounding effect of the pupils coming from families with a washing machine. However, the findings were not statistically significant. There was no association between low birth weight and academic achievement of the students at grade 7 (OR=1.59 p=0.28, 95% CI (0.68; 3.69)).

The odds of achieving the low scores in Mathematics at grade 7 for severely stunted (z-score <-3) children was 2.75 (p=0.05, 95%CI (1.01; 7.45) fold elevated than when not stunted adjusting for age at grade 7 and family owning the house they live in. And, when the z-score was below -4 the odds of achieving the low scores were 7.38 times more for severely stunted (p=0.03, 95%CI (1.22;44.67)) adjusting for family owning their home.

The findings demonstrated that in this cohort there was no association between the performance in Mathematics at grade 7 and weight-for-age, weight-for-height and BMI-for-age.

Access to a motor car, refrigerator and telephone did not show much variance in the high category for Mathematics.

Table 3.4 Association between Mathematics scores and socio-demographic factors

Factors	Education performance in Mathematics at grade 7					
	Univariate Analysis			Multivariate Analysis		
	Crude OR	**P-value**	**95% CI**	**Crude OR**	**P-value**	**95%CI**
Gender Males Females (washing machine)	 1 1.29	 0.32	 0.77;2.18	 1 1.17 **2.1**	 0.55 **0.02**	 0.69;1.99 **1.11; 4.27**
Birth weight (g) >= 2500g Low(<2500g)	 1 1.40	 0.42	 0.61;3.24	 1.59	 0.28	 0.68;3.69
Height-for-age z-score >= -2 z-score <-2 (age @grade 7) (own house) z-score <-3 (age @grade 7) (washing machin) z-score <-4 (own home)	 1 0.91 2.58 **6.91**	 0.73 0.06 **0.03**	 0.53;1.55 0.98; 6.82 **1.16;41.20**	 1.06 **0.67** **2.30** **2.75** **0.67** **2.31** **7.38** **1.97**	 0.84 **0.001** **0.02** **0.05** **0.001** **0.02** **0.03** **0.03**	 0.62;1.82 **0.52;0.85** **1.16;4.57** **1.01;7.45** **0.52;0.85** **1.16;4.60** **1.22;44.67** **1.08;3.59**
Weight-for-age z-score >= -2 z-score <-2	 1 1.22	 0.64	 0.52;2.84	 1.29	 0.59	 0.55;3.02
Weight-for-height z-score >= -2 z-score <-2	1 1.41	 0.50	 0.51;3.95	 1.63	 0.36	 0.57;4.67
BMI-for-age z-score>=-2 z-score <-2	 1 1.52	 0.45	 0.51;4.60	 1.65	 0.37	 0.55;4.99

Table 3.5 illustrated that the odds of achieving a high score in English or first were 2.48 times higher than for males, adjusting for the confounding effect of living in a home with electricity (p=0.01, 95% CI (1.23;5.02)). The results showed no association between birth weight and school performance in English or first language.

In addition, findings for an association between height-for-age at age 2 years and achieving a high score in English or first language were not statistically significant at all categories (z-score <-2, -3 and -4). However, for participants with low weight-for-age at age 2 years the risk of achieving a low score in English or first language was elevated by 2.96 times higher than in participants who had a z-score weight-for-age equal to and above -2SD (p=0.05, 95% CI (1.00; 8.71)).

Furthermore, the findings showed that there is no association between education performance in English or first language and weight-for-height and BMI-for-age.

Table 3.5 Association between English or first language scores and socio-demographic factors

Factors	**Education performance in English/1st language at grade 7**					
	Univariate Analysis			**Multivariate Analysis**		
	Crude OR	**P-value**	**95% CI**	**Crude OR**	**P-value**	**95%CI**
Gender Males Females (electricity)	 1 **2.31**	 **0.02**	 **1.16;4.62**	 **2.48** **16.1**	 **0.01** **0.05**	 **1.23;5.02** **1.01;255.9**
Birth weight (g) >= 2500g Low(<2500g)	 1 1.50	 0.46	 0.52;4.37	 1.23	 0.72	 0.39;3.90
Height-for-age z-score >= -2 z-score <-2 z-score <-3 z-score <-4	 1 0.73 0.82 1.71	 0.38 0.78 0.63	 0.37;1.46 0.20;3.30 0.19;15.48	 0.86 0.96 2.45	 0.70 0.95 0.43	 0.41;1.81 0.24;3.83 0.26;22.85
Weight-for-age z-score >= -2 z-score <-2 (motor vehicle) (age@grd7)	 1 2.36	 0.11	 0.84;6.66	 **2.96** **2.04** **0.41**	 **0.05** **0.051** **0.00**	 **1.00;8.71** **0.99;4.20** **0.28;0.60**
Weight-for-height z-score >= -2 z-score <-2	 1 1.76	 0.39	 0.48;6.48	 2.89	 0.13	 0.74;11.39
BMI-for-age z-score>=-2 z-score <-2	 1 2.48	 0.22	 0.57;10.75	 3.61	 0.11	 0.75;17.49

CHAPTER 4

4.0 Discussion and Conclusion

4.1 Introduction

The main objective of this paper was to examine if an association exists between height at age 2 years, in particular stunting, and education performance at grade 7 at the end of primary school. Mathematics and English or first language scores were selected as markers of education performance. Consistent with other studies [1,35-37,39,54-57,70,71] the findings in this study showed that there is an association between stunting in early years, and diminished school performance later in life.

The association between height and academic performance was documented as early as 1892. Porter (1892) reported his findings on association between height and school performance in a study involving 33 500 students of both sexes at St Louis Board of Public Schools. Measures of growth such as weight, height, length and breadth of head and other factors were documented. He observed that taller students performed better academically than their shorter peers[72]. There has since been a growing large body of evidence that has confirmed his findings.

4.1 Association between height at age 2 years and education performance at grade 7

In this study we showed that there was an association between stunting at age 2 years and school performance at last year of primary school (P=0.05 at Z-score <-3) and (P=0.04 at Z-score <-4).

These data were consistent with the findings from other South African studies and other LMICs including Nigeria, Pakistan, Guatemala, Jamaica, Ecuador, India, and the Phillipines[1,37,40,49,50-57] as tabulated in Table4.1. Stunting due to malnutrition can have serious long term ramifications for the children involved.

For example, in Barbados, children born between 1967 and 1972 who suffered from kwashiorkor and marasmus in early childhood due to malnutrition, scored lower in IQ and conservation tests at adolescence.[70] Again, in 1999 the Philippines, children who were short-for-age at 2 years were outperformed by their peers in cognitive ability tests at ages 8 and 11years.[1] Children who performed better in Mathematics and language at primary school in the United Kingdom were more likely to have a brighter future economically [49].

The South African findings seem to echo other international findings as seen in Table 4.1. As such, measured have to be put in place to avert growth retardation in young children in South Africa. For stunted children, interventions that can facilitate catch-up growth need to be explored.

4.1.1 Association between weight-for-age, weight-for-height, BMI-for-age and school performance at grade 7

Our results showed a strong association between low weight-for-age and poor school performance in English or first language (P=0.04). Consistent with our findings, Abidoye et al. (2000) showed that there was an association between nutritional status defined by weight-for-age Z-scores and poor school performance in Nigerian school children (P<0.05)[50].

We did not find any association between obesity (defined by BMI-for-age) school performance. This could have been due to the fact that there were very low levels of obesity and wasting in our study sample. Therefore, small sample size could have been a contributing factor. On the contrary, in a study conducted in Thailand including children in grades 3-6 and 7-9, children who were overweight faired lower in school compared to children with normal weight.[90/73]

4.1.2 School performance at grade 7 in Mathematics and English or first language

Even though levels of stunting at age 2 years were split 50/50 between males and females, data analysis showed that females outperformed males in both Mathematics and English or first language; and the results were highly significant for English or first language with P<0.0001.

A taller stature, possibly an indicator of better nutrition, also seemed to be more beneficial for males than females in achieving a high score in Mathematics because taller males performed better in Mathematics and contrary to our expectations, shorter females performed better in the same subject. We could hypothesise that this could be attributed to genetic short stature as opposed to stunting due to under-nutrition. There was a positive correlation between some socio-economic indicators and education performance at grade 7.

Maternal education correlated positively with achieving high score in both subjects and the results were highly significant for English or first language (P=0.014), but the not for Mathematics. Similarly, this correlation was also observed in American and Nigerian studies[50,87/74].

Ownership of assets such electricity, washing machine, motor vehicle and living in a house; which are a sign of better socio-economic status; showed to have a positive correlation to school performance. On the other hand, children from homes with television performed badly in both Mathematics and English or child's first language compared to those without access to television, however, only correlation between Mathematics and having a motor car at home results were statistically significant. This could be due to lack of supervision by the parents resulting in children watching long hours of television instead of attending to their studies. According to a report by Dr. Jane M. Healy (1998)**,** there is a positive correlation between high levels of television viewing and low academic performance[88/75].

4.1.3 School performance, number of times repeated grade/s and age at grade7

The results of logistic regression of number of times the pupil repeated a grade and age at grade 7 showed that the older children were the mostly likely to repeat a grade (P<0.0001).This was expected because these were the children presumed to be slower academically and were older than their peers because they had to repeat certain grades.

The study did not explore other factors that could contribute to children repeating grades, for example; chronic absenteeism, and orphan-hood (an estimated 12 million children in Sub-Saharan Africa have lost parents to AIDS)[89/76] racism, bullying and teacher to child class ratio amongst others[77]. These are factors that could be further investigated within this cohort.

4.1.4 Stunting at age 2 years and distribution of measures of socio-economic status

While at age 2 years the mean z-score for all anthropometric measures utilized in the study was above -2SD, a substantial proportion of the study participants were stunted. From the graphical presentation (Figures 3.1) we could see that a significant proportion of the children were short-for-age (stunted).

Stunting is attributed to poverty as the underlying factor which causes malnutrition resulting in growth retardation. According to the South African Constitution, Section 28(1) (c) of the Bill of Rights, every child has a right to basic nutrition [73/77.] On the contrary, in 2002, child hunger (“children reported to go hungry “sometimes”, “often”, “always” because there was not enough food”) was estimated to be 29.7% in South Africa and 17% in Gauteng [74/78]. On average, the study participants in this research project were 13 years old and in grade 7 between 2002 and 2003 when Lake and colleagues reported the findings.

Maternal education is one of the most important determinants in child development [66,67,75/79]. This was also highlighted in a Ugandan study which showed that children born to mothers with little or no education were 2.1 times more likely to be stunted than their counterparts [76]. Likewise, the odds of being stunted in children were reduced with increased maternal and paternal education in Bangladesh and Indonesia[75].

In South Africa, a majority of parents or guardians do not always have the necessary skills to assist their children academically which might explain the poor performance of some children[77]. This was also reflected in our analysis which showed a correlation between pupil’s poor school performance and lower maternal education. Also, the ability to acquire higher education is very much linked to one’s socio-economic status. According to Business Report (September, 28 2009), Professor Bhorat from the University of Cape Town told the South African Parliamentary briefing that South Africa was “the most unequal society in the world”, with a GINI coefficient index (the number between 0 and 1 - which is a measure of inequality in a society. A number close to 0 represents a fairly equal society and a number close to 1 represents an unequal society [78]) at 0.679 [79].

The proportion of families living in formal housing in Gauteng varied from 1996, 2001 and 2007 from 74.2%, 74.6% and 73.7% respectively [55]. This is much higher than was observed in our study analysis (16.53%). Part of the variation can be explained by the low representation of other population groups as almost 90% of our analytic group were African. In addition, the definition of "formal housing or dwelling" deferred slightly between the two studies. According to Statistics South Africa a "'formal dwelling' includes the following categories: house, flat, semi-detached house, unit in a complex (e.g. simplex), room in backyard and room not in backyard"[80]. In our study formal housing was comprised of a flat, house, shared house and a room.

However, the study demonstrated increased levels of access to running water, electricity, flush toilet, and telephone compared to housing.

4.1.5 Prevalence of Stunting, under weight, wasting and obesity at age 2 years

In general, stunting seems to be a problem within the South African youth. In 1999 an estimated 23% of children in South Africa between the ages of 1 and 3 were stunted. The results showed some headways in the reduction in prevalence of stunting between 1999 and 2005, except for Limpopo province where the levels increased by 0.7%[81]. Overall, the country had a 4% reduction over this period. These findings were consistent with those reported by Steyn and colleagues (19.3 %) also in 2005[82].

Willey et al. (2009) examined the levels of stunting within the Bt20 cohort in 1186 children below the age of three years showed that 213 children (18%) were stunted.

Of these 213 children, 52.3% had height data form the 2-year assessment available with 24.5% defined as stunted. From the 35.2% of children form the 1-year assessment, 7.7% were stunted and 19.7% were classified as stunted from 12.4% of data collected at the 6-month assessment [83].

Additionally, Kimani-Murage et al (2010) investigated the prevalence of stunting, overweight/obesity and risk of metabolic disease in rural South Africa. There were 3511 children and adolescents aged 1-20 years involved in the study. The prevalence of stunting was significantly higher in boys than girls at ages 6, 14 and 15 years old. An estimated 25% of the children aged 1-4 years old were stunted; of which one in three were aged 1 years old[84].

Amongst this cohort, there were equal proportions of males and females. These findings were in contradiction to other African studies where stunting differentials favoured females [14,76].

At birth more than 97% of study the participants presented with healthy growth standards. Conversely, the results showed significant retardation in growth from birth to age 2 years. Similarly, a study conducted in Limpopo, South Africa, revealed increased levels of stunting in children between one month and 12 months in infants. In the study, at birth 9.6% of the infants were stunted, however, at 12 months the prevalence had increased to 34.6% within the cohort.[83] This high prevalence was consistent with other findings in Limpopo[81,84,85]. The researchers attribute this to the poor feeding practices introduced to some of the infants in early infancy[83].

This is crucial information as it may provide evidence of when infants are most vulnerable to under-nutrition in underprivileged South African communities. This would suggest that interventions need to be implemented in communities from birth to the age of two years in additional to school feeding schemes that are already in place.

Our findings are much higher than those reported by Labadarios and colleagues (1999) where stunting was reported to be 17% in urban South Africa, but lower than in Limpopo where stunting was accounted to be as high as 34%[11,8]. Consistent with our findings, other studies have also shown lower levels of obesity compared to stunting among children in South Africa[82,86]. There was minimal exhibition of malnutrition in the form of wasting and, underweight in this study cohort.

Table 4.1 Impact of growth-restriction (stunting) in young children in developed and developing countries			
Country	**Setting**	**Association between stunting and poor school performance or cognitive development**	**Reference**
UK	Longitudinal study -National Child Developmental study. Children born in Great Britain, 3-9 March, 1958. (n~1700)	Positive	Currie et al. (1999)
Nigeria	Primary school pupils exposed to different nutritional and health status in Nsukka, Enugu State of Nigeria. (n=275)	Positive	Abidoye et al. (2000)
Pakistan	Longitudinal study – infants born between 1984 and 1987 in four different areas of Lahore, Pakistan. (n=1014)	Positive – ($p<0.05$)	Cheung et al. (2001)
Guatemala	Longitudinal study of children born between January 1, 1969 and February 28, 1977 from 179 villages located in the Department of El Progreso, northeast of Guatemalan City. (n=2393)	Positive	Pollit et al. (1993)
Jamaica	Follow-up study to ascertain if gains in cognition and school achievements achieved by stunted children in Kingston, Jamaica; in early childhood through supplementary diet and psychosocial stimulation were sustained in late adolescence. (n=103)	Stunted children outperformed by their non-stunted counterparts ($p< 0.05$)	Walker et al. (2005)
Ecuador	Children selected from 158 parishes in six provinces in Equador. (n=3,153) 23.4% on the children were stunted.	Positive association between height, weight, maternal education and cognitive development.	Paxson. (2005)

Guatemala	Investigating effects of growth, environment and psychosocial risks on number of years of school achieved in adolescents in rural Guatemala. (n=333)	Taller children completed more years of school than their shorter peers.	Stith et al. (2003)
India	Data collected across Indian States to estimate effects of wealth on education enrollment.	Overall, rich children are 31%-42% more likely to be enrolled in school than poor children.	Filmer et al. (2001)
Philippines	The Cebu Longitudinal Health and Nutrition Survey (CLHNS)- analyzes association between stunting at 2 years and cognitive development in late childhood in a cohort of Filipino children . (n=2,131)	Positive	Mendez et al. (1999)
South Africa	1955 - Longitudinal study involving Cape Coloured children between the ages of 10-16 months, to examine the impact of under-nutrition in the first 2 years of a child's life on intellectual development.	Positive	Stoch et al. (1963)
Philippines	Association between height at age 2 years and schooling trajectory through high school in children from CLHNS. (n=2198)	Taller children were less likely to repeat grades or drop out of school before they finish high school compared to short children.	Daniels et al. (2004)
South Africa	Grade 2 school children from three primary schools in Uhlamba, Kwa-Zulu Natal.	Positive	Liddell et al. (2001)
Jamaica	Stunted children aged 9months to 2 years old participated in a 2-year randomized trial of supplementation and psychosocial stimulation. Eight years later at 11 and 12 years they were assessed for growth IQ and cognitive function.	Supplementation had no effect on growth and cognition in stunted children.	Walker et al. (2000)

4.8 Limitations to the study

The study sample was not representative of the South African population as a whole. The study was conducted in one South African urban location and did not include any rural locations in South Africa. Therefore, the findings could be different in other areas of South Africa.

There were some variations in the marking and scoring systems used by the different primary schools included in the study as tabulated in Table 2.2, even though these data were recoded, standardized bias may have been introduced in the process. South African primary schools do not have a uniform grading method. This makes it more difficult to evaluate school results from different schools when standardized tests where not utilized.

The study did not account for differences in resources between former model C schools and township schools. These differences in resources could possibly impact on how children perform in schools. We also did not assess if better resources in former model C schools afforded study participants an advantage in education scores over those attending previously disadvantaged schools.

We did not explore possible confounders such as absenteeism, teacher to pupil ratio in different schools, quality of teaching, hunger, racism, bullying, and distance travelled to and from school; as all these factors may weigh heavily on how a student performs.

Some of the education performance data was missing resulting in a reduction of our sample size. Even though study participants were requested to submit all their school reports, at times they failed to comply with this request for various reasons; including embarrassment when one did not perform well or sometimes the pupil had dropped out of school and does not notify the study site.

4.9 Conclusion

4.9.1 Implications of the study

The ramifications of poverty and how it can permeate social development of a nation cannot be overstated. Figure 4.2 illustrates a constructed argument based on literature review and study results of adverse effects of poverty from the time a child is conceived to growth and development; leading up to future earnings in adulthood -taking cognisance of the limitations of our study. This can have huge implications for a developing country such as South Africa.

Schuftan (1975) argues that malnutrition is not the ultimate cause of poor performance in school children but a symptom of the problem. He posits that poverty is the syndrome that accounts for the malnutrition and other factors that prevail in poor environments leading to poor development of young children and subsequently poor school performance and low intellectual quotient. He therefore suggests that in order to uplift these communities measures have to be put in place to address the root of the problem which is poverty.[71] Education is key in poverty alleviation.

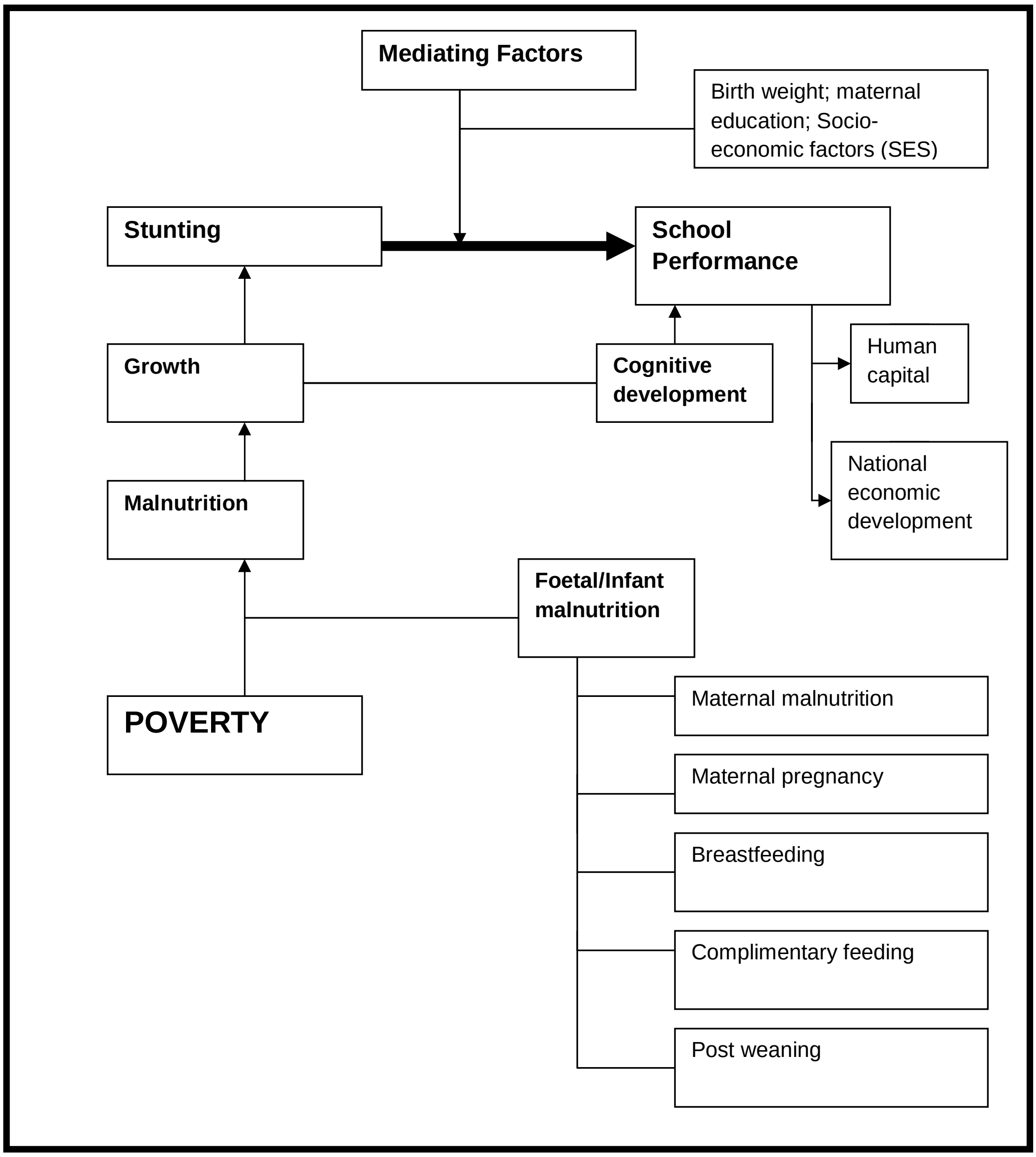

Figure 4.2 Summary Diagram

Level of education has always been used as proxy for human capital. Contrary to the previous studies that have shown that there is no correlation between years of schooling and economic growth, Cohen and Soto (2007) amongst others have shown that there is a strong association between the two variables using data sets from 95 countries[1,37,40,50,49,50-57]. It is therefore crucial that if stunting has such detrimental effects in the education performance of young adolescents that radical initiatives are employed to address the problem. The future development of South Africa lies heavily on the success of young people in our country. Grantham-McGregor states that the association between stunting and poor development is not important only to the individual concerned but also to the nation as a whole[6]. We therefore add that in addition to all the means employed by the government to improve the education system in South Africa; it is important to address the issue of poor child development from the rudimentary levels, which include maternal education to achieve healthy pregnancy and fitness for pregnant women, healthy infancy, and elimination of under-nutrition in early age for the betterment of the nation.

In conclusion, under-nutrition at an early age of a child's life, especially under the age of two years, is detrimental to the well being of all children. The results of the study showed high prevalence rates of stunting within the study cohort and a strong association between stunting and poor school performance at adolescence. As mentioned earlier, there are very few studies showing correlation between stunting and cognitive development conducted in LMICs. Information such as this is important not only for the individuals involved but also for the development of South Africa, and Africa as a whole.

4.9.2 Future direction

Long term studies to examine early growth and matric or tertiary outcomes or human capital are needed to evaluate the long-term impact on young people in our society.

4.9.3 Reflections

What I have learned is that sufficient time is required for one to conduct good scientific research. The process thought me the value of good data, as they say, there is not much one can do with bad data no matter how skilled one is.

I learned the importance of collecting data diligently to avoid problems of missing data and as well dealing with missing data. It was also alarming to see how easy the sample size could drop due to missing data. I was fortunate in that I was exposed to knowledgeable individuals who challenged and nurtured me as well.

4.9.4 Recommendations

1. The study has shown that stunting is a potential problem for South Africa, and reinforced high prevalence levels of stunting in the country as noted in other studies. We do recognise that stunting levels in the Johannesburg-Soweto area could have decreased since 1991/2. Further studies will need to be conducted to substantiate these findings in contemporary urban South Africa.

2. Richard Horton suggests that there are scientifically proven methods that can be employed to reduce levels of malnutrition and its detrimental effects. These include

proper breastfeeding practices, zinc fortification and supplementation with iron, folic acid and other micronutrients[9].

3. Therefore it is very important that government and other organizations are lobbied around the consequences of malnutrition and the possible solutions to the problem.

5. Lastly, every mother wants a healthy baby; information relating to healthy pregnancy and healthy child development should be made more available through a variety of media and health services.

APPENDICES

APPENDIX A

Table A1 Checking and cleaning data for discrepancies between data captured and paper data (for all grades)

	Electronic – No Paper		**Paper – No electronic**	
	Frequency	Relative Freq.	Frequency	Relative Freq.
Blanks (no data recoded)	1	0.22%	1	0.22%
No (electronic / paper data)	122	27.05%	112	24.83%
Yes(electronic / paper data)	328	72.73%	338	74.95%
Total (electronic / paper data)	451	100%	451	100%

APPENDIX B

Table A2 Checking and cleaning data in Table A1 for discrepancies between data captured and paper data (for grade 7 only)

	Electronic – No Paper		**Paper – No electronic**	
	Frequency Freq.	Relative	Frequency Freq.	Relative
Blanks (no data recoded)	0	0	0	0
No	4	9.52%	2	4.76%
Yes	38	90.48%	40	95.24%
Total	42	100%	42	100%

APPENDIX C

Table A3 Checking and cleaning data for discrepancies between data captured and paper data (for grade 7 only using a new sample from one used in Table A1&2)

	Electronic – No Paper		Paper – No electronic	
	Frequency	Relative Freq.	Frequency	Relative Freq.
No (no data captured)	2	4.4%	1	2.2%
Yes	3	6.6%	3	6.7%
No variance	40	89.0%	41	91.1%
Total	45	100.0%	45	100.0%

APPENDIX D

Table A4 Common errors between data captured and paper data

Common errors in the data	# of cases detected
Wrong surname captured (electronic)	1
Language captured as 1st language instead of English (electronic)	2
Language captured as 1st language instead of vernacular (electronic)	1
1st language not stipulated, captured as 1st language (electronic)	2
Front page of the report missing, no school name or grade	13
Page for school marks missing (paper)	1
Grade 1 reports marks not entered on the computer	1
Original report in year 16 file	3
Date not stated on the report card	3
No paper but electronic data captured	3
Information not captured electronically	3
Grade not known	5
Participant excluded from the study (some have migrated)	2
No reports in the file – not captured electronically either.	7
BTT identity number captured wrongly electronically and on the paper	1
Electronic report shows grade 5 instead of grade 4	1
Grade1,3,4 results not captured electronically	4

APPENDIX E

Table A5 Distribution of languages used to define 1st language at grade 7

Language	Frequency		Relative frequency	
	Sample 1	**Sample 2**	**Sample 1**	**Sample 2**
English	19	25	45.24%	55.56%
First language (not stipulated)	7	12	16.67%	26.67%
Afrikaans	6	0	14.29%	0%
Zulu	5	2	11.90%	4.44%
Sepedi	1	0	2.38%	0%
Sotho	0	2	0%	4.44%
Tswana	0	1	0	2.22%
Vernacular	3	1	7.14%	2.22%
African language	1	0	2.38%	0%
No documents on the file and not captured electronically either	0	2	0%	4.44%
Total	42	45	100.0%	100%

APPENDIX F

UNIVERSITY OF WITWATERSRAND HUMAN RESEARCH ETHICS CLEARANCE LETTER

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Nkomo

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M081004**
PROJECT	Association between Height at Age 2 Years Old and Adolescence School Performance: Evidence from BT20 Cohort Study
INVESTIGATORS	Miss PM Nkomo
DEPARTMENT	Birth to Twenty
DATE CONSIDERED	08.10.31
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 08.11.03 **CHAIRPERSON** ....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : C Ginsburg

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

References

1. Mendez MA, Adair LS. Severity and timing of stunting in the first two years of life affects performance on cognitive tests in late childhood. Journal of Nutrition 1999;129:1555–1562.

2. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter LM, Strupp L. Child development in developing countries: Developmental potential in the first5 days for children in developing countries. The Lancet 2007, 369:60-70.

3. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and undernutrition 2 maternal and child undernutrition: consequences for adult health and human capital. Lancet 2008, 371:340-357.

4. Victora, C.; Adair, L.; Fall, C.; Hallal, P.; Martorell, R.; Richter, L.; & Sachdev, H. 2007. < http://www-tc.iaea.org/tcweb/abouttc/tcseminar/Sem6-ExeSum.pdf>

5. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and Undernutrition 1, Maternal and child Undernutrition: global and regional exposures and health consequences. The Lancet 2008; 371(9608): 243-260.

6. WHO Child Growth Standards. (2006)<

http://www.who.int/childgrowth/standards/Technical_report.pdf> [Accessed 05.04.2008]

7. Grantham-McGregor S. Commentary: Linear growth retardation and cognition. 2002. The Lancet 2002; 359:542-542.

8. Cameron N. Physical growth in a transitional economy: The aftermath of South African Apartheid. Economics of Human Biology 2003, 1(1):29-42.

9. The Lancet: Media Invitation and Press Release, 2008. < https://www.who.int/nutrition/topics/Lancetseries_MediaAdvisory_UK.pdf> [Accessed 20.05.2008]

10. South African Vitamin A Consultative Group (SAVACG). Anthropometric, Vitamin A, iron and immunisation coverage status in children aged 6-71 months in South Africa, 2004. South African Medical Journal1996 April; 86(4):354-7.

11. Labadarios D, Steyn N, Maunder E, et al. The National Food Consumption Survey (NFCS): Children Aged 1 - 9 years, South Africa, 1999. Pretoria: Department of Health 2000; 193-206.

12. Jinabhai CC, Taylor M, Sullivan KR. Implications of the prevalence of stunting, overweight and obesity amongst SA School children: A possible nutritional transition. European Journal of clinical Nutrition 2003; 57: 358–365.

13. Lewit E M, Kernebrock N. Children and Poverty. The Future of Children 1997; 7(2):149 – 156.

14. Zere A, McIntyre D. Inequality in under-five child malnutrition in South Africa. International Journal of Equity in Health 2003; 2:7.

15. Healthy Active Kids, South Africa. South African Report card on Physical Activity for children and youth: Promotion of healthy eating, prevention of obesity and stunting. 2007< http://www.mrc.ac.za/chronic/healthykids.pdf> [Accessed 20.05.2008]

16. Mendoza-Salonga A. Nutrition and brain development. SA Fam Pract 2007:49(3). < http://www.safpj.co.za/index.php/safpj/article/view/812/694> [Accessed 01.22.2009]

17. Theron M, Amissah A, Kleynhans IC, Albertse E, MacIntyre UE. Inadequate dietary intake is not the cause of stunting amongst young children living in an informal settlement in Gauteng. Public Health Nutrition 2006; 10(4):379–389.

18. Kelly RW. Nutrition and placental development. Proc. Nutr. Soc. Aust. 1992; 17:203-211

19. Widdowson EM, McCance RA. A Review: New Thoughts on Growth. Paediatrics Research 1975; 9:154-156.

20. Belkacemi L, Nelson DM, Desai M. Maternal Undernutrition Influences Placental-Fetal Development. Biology of Reproduction 2010; 83(3):325-331.

21. Widdowson EM, McCance RA. A Review: New Thoughts on Growth. Paediatrics Research 1975; 9:154-156.

22. de Onis M. Intrauterine Growth Retardation. 2020 Focus 5 (Health and Nutrition Emerging and Reemerging Issues in Developing Countries), Brief 6 of 11, February 2001http://www.soilandhealth.org/01aglibrary/Arun/Health%20and%20nutrition%20of%20children%20in%20developing%20countries.pdf [Accessed 20.10.2010].

23. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull World Health Organization 1987; 65:663-737.

24. Kramer MS, Victora C. Low birth weight and perinatal mortality. Nutrition and Health in developing countries. Humana Press 2001. 10th Edition: 57-70. <http://books.google.co.za/books?hl=en&lr=&id=7JYvVV0hg2kC&oi=fnd&pg=PA57&dq=Kramer+MS,+Victora+C.+&ots=lrWDSQ1TZu&sig=gSGAjfSOHZFanxo8A0Djbxhf9c0#v=onepage&q=Kramer%20MS%2C%20Victora%20C.&f=false> [Accessed 21.05.2008]

25. World Health Organization. Maternal anthropometry and pregnancy outcomes: A WHO Collaborative Study. Bull World Health Organ. 1995; 73 (Suppl): 1–98.

26. Martin RM, Davey Smith G, Mangtani P, Frankel S, Gunnell D. Association between breastfeeding and growth: the Boyd-Orr cohort study. Arch. Dis. Child Fetal Neonatal.Ed. 2002; 87: F193-F201.

27. Van der Merwe J, Bourne L, Marais D. An assessment of preliminary food-based dietary guidelines for infants 6-12 months of age in the Karoo area of the Western Cape Province of South Africa. Public Heath Nutrition, 2006; 10(9):869-877.

28. Ford R, Taylor B, Mitchell E, Enright S, Stewart A,Becroft D, et al. Breastfeeding and the risk of sudden infant death syndrome. International Journal of Epidemiology 1993; 22:885–890.

29. Kramer MS, Ritsuko Kakuma. The optimal duration of exclusive breastfeeding: A Systemic Review. WHO. 2002. http://www.who.int/nutrition/publications/optimal_duration_of_exc_bfeeding_review_eng.pdf [accessed 29.10.2010].

30. WHO, 2001. Guiding principles for complimentary feeding. http://whqlibdoc.who.int/paho/2003/a85622.pdf [Accessed 29.10.2010].

31. Delport SD, Becker PJ, Bergh A. Growth, feeding practices and infections in black infants. South African Mecical Journal 1997; 87:57-61.

32. Mamabolo RL, Alberts M, Mbenyane GX, Steyn NP, Nthangeni NG, Delamarre-van de Waal A, et al. Feeding practices and growth of infants from birth to 12 months in the central region of the Limpopo Province of South Africa. Nutrition 2004; 20:327-333.

33. Bourne LT. South African paediatric food-based dietary guidelines. Maternal and Child Nutrition 2007; 3:227-229.

34. Becker S, Black RE, Brown KH. Relative effects of diarrhea, fever, and dietary energy intake on weight gain in rural Bangladeshi children. American Journal of Clinical Nutrition 1991; 53: 1499-1503.

35. Chang SM, Walker SP, Grantham-McGregor S, Powell CA. Early childhood stunting and later behaviour and school achievement. Journal of Child Psychology and Psychiatry 2002; 43(6):775-783.

36. Richards M, Hardy R, Kuh D, Wadsworth MEJ**.** Birthweight, postnatal growth and cognitive function in a national UK birth cohort. International Journal of Epidemiology 2002; 31:342-348.

37. Walker SP, Chang SM., Powell CA, Simonoff E, Grantham-McGregor SM. Early Childhood stunting is associated with poor psychological functioning in late Adolescence and Effects are Reduced by Psychosocial stimulation. American Society for Nutrition 2007; 2464-2469.

38. Stoch MB, Smythe PM. Does Undernutrition During Infancy Inhibit Brain Growth and Subsequent Intellectual Development? Reprinted with permission from Arch Dis Child 1963; 38:546 II and From the Department of Child Health, Red Cross War Memorial Children's Hospital and University of Cape Town, South Africa. Nutrition 1996; 12:74.

39. Griesel RD, Richter LM. Undernutrition, brain growth and intellectual development. The South African Medical Journal 2006; 96(9): 862.

40. Stoch MB, Smythe PM. Does undernutrition during infancy inhibit brain growth and subsequent intellectual development. Arch. Dis. Childh 1963;38 :546-552.

41. Stockard CR. Developmental rate and structural expression: an Experimental study of twins, "double monsters" and single deformities, and the Interaction among embryonic organs during their origin and development. American Journal of Anatomy 1920; 28:115–277.

42. Barker DJP. Mothers, Babies, and Disease in Later Life: Programming the

baby. Nutrition 1997; 13:807-813.

43. Fowden AL. Endocrine regulation of fetal growth. Reproduction, Fertility and Development 1995; 7(3):351-363.

44. Berger A. Insulin like growth factor and cognitive function. MBJ 2001; 322:203.

45. Hack M, Schluchter M, Cartar L, Rahman M, Cuttler L, Borawski E. Growth of Very Low Birth Weight Infants to Age 20 Years. Paediatrics 2003;112:e30-e38.

46. Marmot MG, Bomsa H, Hemingway H, Brunner E, Stansfeld S. Contributions of job control and other risk factors to social variations in the coronary heart disease incidence. The Lancet 1997; 350:235-39.

47. Winick M. Malnutrition and brain development. J Paediatrics 1969; 74(5): 667-79.

48. Lucas A. Programming by early nutrition in man. The childhood environment and adult disease. Wiley, Chichester. Ciba Foundation Symposium; 156: 38-55.< http://www.earlylearning.ubc.ca/documents/development-health/Lucas%20A,%201991.pdf>[Accessed 19.05.2008]

49. Currie J, Thomas D. Early Test Scores, Socio-economic Status and Future Outcomes. 1999.< http://www.nber.org/papers/w6943.pdf?new_window=1> [Accessed 17.10.2009]

50. Abidoye RO, Eze DI. Comparative School Performance through better Health and Nutrition in Nsukka, Enugu, Nigeria. Nutrition Research 2000; 20 (5):609-620.

51. Cheung YB, Yip PSF, Karlberg JPE. Fetal growth, early postnatal growth and motor development in Pakistani infants. International Journal of Epidemiology 2001; 30:66-74.

52. Pollit E, Gorman K, Engle PL, Martorell R, Rivera J. Early supplementary feeding and cognition: Effects of over two decades. <http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1012&context=psycd_fac>[Accessed 19.01.2010]

53. Paxson C, Schady N. Cognitive development among young children in Ecuador: The roles of wealth, health and parenting. World Bank Policy Research Working Paper 3605, May 2005. < http://papers.ssrn.com/sol3/papers.cfm?abstract_id=753548>

54. Stith AY, Gorman KS, Choudhury N. The Effects of Psychosocial Risk and Gender on School Attainment in Guatemala. Applied Psychology: An International Review 2003; 52(4): 641-629.

55. Filmer D, Pritchett LH. Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application to Educational Enrolments in States of India. Demography 2001; 38(1):115-132.

56. Daniels MC, Adair LS. Growth in Young Filipino Children Predicts Schooling Trajectories through High School. Journal of Nutrition 2004; 134:1439–1446.

57. Liddell C, Rae G. Predicting early grade retention: A longitudinal investigation of primary school progress in a sample of rural South African children. British Journal of Educational Psychology 2001; 71:413-428.

58. Shonkoff JP, Phillips D. From neurons to neighbourhood: The Science of Childhood Development. National Research Council Institute of Medicine (US). National Academies Press; 2000. National Academy of Sciences. Fourth Edition.

59. Theron M, Amissah A, Kleynhans IC, Alberts E, MacIntyre UE. Inadequate dietary intake is not the cause of stunting amongst young children living in an informal settlement in Gauteng and rural Limpopo Province in SA: The Nutri-Gro study. Public Health Nutrition 2006; 10(4):379 – 389.

60. Millennium Development Goal (MDG) <http://www.un.org/millenniumgoals/>[Accessed 28.09.2009]

61. Malnutrition. <https://vula.uct.ac.za/access/content/group/91e9e9d8-39b6-4654-00ae-f4d74cba085f/CD%20Volume%207%20Appendix%201%20Malnutrition.pdf>[Accessed 10.03.2010]

62. Mieke Faber M, Wenhold F. Nutrition in Contemporary Africa. 2006. <http://ajol.info/index.php/wsa/article/viewFile/49122/35467>[Accessed 10.03.2010]

63. Joubert G, Ehrlich R. 2007. Epidemiology. A Research Manual for South Africa. 2nd Edition. Oxford University Press Southern Africa.

64. Ramakrishnan U. Nutrition and low birth weight: From research to practice. American Journal of Clinical Nutrition 2004; 79:17-21.

65. Thomas D, Strauss J, Henrique M-H. How does Mother's Education affect Child Height. The Journal of Human Resources 1991; 26(2):183-211.

66. McCrary J, Royer H. The Effect of Female Education on Fertility and Infant Health: Evidence from School Entry Policies Using Exact Date of Birth

Working Paper 12329 <http://www.nber.org/papers/w12329: 2005/6>.[Accessed 11.04.2009]

67. Zere E, and McIntyre D. Inequities in under-five child malnutrition in South Africa. Int J Equity Health 2003 September 11; 2:7.

68. Richter L, Strupp B. The International group of Child Development Steering group. Development potential in the first 5 years for children in developing countries. The Lancet 2007 January 6; 369:60-70.

69. Richter LM, Norris SA, De Wet T. Transition from Birth to Ten to Birth to Twenty: the South African cohort reaches 13 years of age. Paediatr Perinat Epidemiol 2004; 18(4): 290–301.

70. Galler JR, Ramsey FC, Forde V, Salt P, Archer E. Long-Term Effects of Early Kwashiorkor Compared with Marasmus. II. Intelectual Performance. Journal of Pediatric Gastroenterology and Nutrition 1987; 6: 847-854.

71. Schuftan C, Valenzuela M, LOpez V, Zapata R, Jaque G, Gattas V, Aguayo M. Low School Performance: Malnutrition or Cultural Deprivation? Arch Latinoam Nutr. 1975; 25(2):121-34.

72. Porter WT. The physical basis of precocity and dullness. Transactions of the Academy of Science of St. Louis 1892; 6:161–181.

73. The Constitution of the Republic of South Africa. 1996. Act 108 of 1996.

74. Lakel L, Marera D-H. Nutrition – Statistics on Children in South Africa. Nutrition Child-Hunger. 2009. <http://www.childrencount.ci.org.za/indicator.php?id=4&indicator=32>[Accessed 12.10.2009]

75. Semba RD, de Pee S, Sun K, Sari M, Akhter N, Bloem MW. Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study. The Lancet 2008; 371: 322–28.

76. Wamani H, Åstrøm AN, Peterson S, Tumwine JK4 and Tylleskär T. Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. BMC Pediatrics 2007; 7(17). < http://www.biomedcentral.com/1471-2431/7/17>[Accessed 12.10.2009]

77. Motala S, Dieltiens V, Sayed Y. Physical access to schooling in South Africa: mapping dropout, repetition and age-grade progression in two districts. Comparative Education 2009; 45(2):251-263.

78. GINI Coefficient:

http://www.google.co.za/search?hl=en&defl=en&q=define:Gini+coefficient&sa=X&ei=aW7LTKo3gbvyBrLZuN4B&ved=0CBUQkAE

79. Business Report. South Africa has the widest gap between the rich and poor. Study finds now SA falls below Brazil. September 28, 2009. <http://www.busrep.co.za/index.php?fArticleId=5181018>.[Accessed 11.09.2009]

80. Statistics South Africa. 2007. Statistical Release P0301. Community Survey. <http://www.statssa.gov.za/publications/P0301/P0301.pdf>[Accessed 11.09.2009]

81. Berry L, Hendricks M. Nutrition – Stunting in Children. Children's Institute, University of Cape Town. <http://childrencount.ci.org.za/uploads/factsheet_35.pdf>.[Accessed 11.09.2009]

82. Steyn NP, D. Labadarios D E. Maunder E, C. Lombard C, 2005. Secondary anthropometric data analysis of the National Food Consumption Survey in South Africa: The double burden. Nutrition; 21: 4-13.

83. Ramoteme L. Mamabolo RL, Marianne Alberts M, Gertrude X. Mbenyane GX,Nelia P. Steyn NP, Nndivheni G. Nthangeni NG, Henriette A. Delemarre-van De Waal HA, et

al. Feeding Practices and Growth of Infants From Birth to 12 Months in the Central Region of the Limpopo Province of South Africa. Nutrition 2004; 20:327–333.

84. Kimani-Murage EW, Kahn K, Pettifor JM et al. The prevalence of stunting, overweight and obesity and metabolic disease risk in rural South African children. 2010. BMC Public Health, 10:158.

85. Christina Paxson, Norbert Schady. Cognitive Development Among Young Children in Ecuador: The Roles of Wealth, Health and Parenting. 2005. <http://weblamp.princeton.edu/~chw/papers/paxson_schady_childrenecuador.pdf>[Accessed 15.01.2010]

86. Monyeni KD, van Lenthe FJ, Steyn NP. Obesity: does it occur in African children in a rural community in South Africa? International Journal of Epidemiology 1999; 28:287-292.

87. Davis-Kean PE. The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. Journal of Family Psychology 2005; 19(2): 294–304.

63. Joubert G, Ehrlich R. 2007. Epidemiology. A Research Manual for South Africa. 2nd Edition. Oxford University Press Southern Africa.

88. Healy JM. Understanding TV's effects on developing brain. 1998. <http://www.brainy-child.com/article/tvonbrain.html>[Accessed 13.09.2009]

89. UNAIDS. Report on the global AIDS epidemic. 2008. < http://data.unaids.org/pub/GlobalReport/2008/JC1511_GR08_ExecutiveSummary_en.pdf>[Accessed 17.10.2009]

90. Mo-suwan L, Lebel L , Puetpaiboon A and Junjana C. School performance and weight status of children and young adolescents in a transitional society in Thailand. International Journal of Obesity 1999; 23, 272-277.